Cooperative National Park Resources Studies Unit

ARIZONA

TECHNICAL REPORT NO. 9

VEGETATION OF GRAND CANYON NATIONAL PARK

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University of Arizona/Tucson - National Park Service

The Cooperative National Park Resources Studies Unit/University of Arizona (CPSU/UA) was established August 16, 1973. The unit is funded by the National Park Service and reports to the Western Regional Office, San Francisco; it is located on the campus of the University of Arizona and reports also to the Office of the Vice-President for Research. Administrative assistance is provided by the Western Archeological and Conservation Center, the School of Renewable Natural Resources, and the Department of Ecology and Evolutionary Biology. The unit's professional personnel hold adjunct faculty and/or research associate appointments with the University. The Materials and Ecological Testing Laboratory is maintained at the Western Archeological and Conservation Center, 1415 N. 6th Ave., Tucson, Arizona 85705.

The CPSU/UA provides a multidisciplinary approach to studies in the natural and cultural sciences. Funded projects identified by park management are investigated by National Park Service and university researchers under the coordination of the Unit Leader. Unit members also cooperate with researchers involved in projects funded by non-National Park Service sources in order to obtain scientific information on Park Service lands.

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August 1982

*The order of the first two authors
was determined by the toss of a coin.

NATIONAL PARK SERVICE/UNIVERSITY OF ARIZONA
Contracts No. CX8210-7-0028 and CX8000-9-0033
CONTRIBUTION NO. 017/06

FOREWORD

This technical report is a revised version of "The Vegetation of Grand Canyon National Park," a final report on a five-year cooperative study by the Applied Remote Sensing Program, Office of Arid Lands Studies, University of Arizona (OALS) and the National Park Service (NPS) which was authored by David A. Mouat, Karen L. Reichhardt, and Peter L. Warren, and submitted to the NPS by the OALS in 1981 on completion of their work under USDI National Park Service contracts numbers CX8210-7-0028 and CX8000-9-0033. This Technical Report No. 9 includes two major additions to the original, 1981, report: 1) a major expansion of the methodology section in response to requests from the staff of Grand Canyon National Park, and 2) additional habitat and other ecological information regarding vegetation within the park.

Information from other classification and mapping efforts has aided in the preparation of this revision which includes work by Peter S. Bennett, NPS Research Scientist, who began mapping segments of the North Rim of Grand Canyon National Park during the early 1970's. A detailed map of the canyon-bottom vegetation, bordering the Colorado River, has been produced largely through the efforts of Museum of Northern Arizona scientists under the direction of Steven W. Carothers, based on information from the Colorado River Research Program (Phillips et al. 1977).

The basic classification scheme used for the Grand Canyon maps is that of Brown, Lowe, and Pase (1979). The Brown, Lowe, and Pase system, as it pertained to Grand Canyon, was further clarified through personal discussion with those three scientists. However, Mouat, Reichhardt, and Warren refined the final scheme and developed the type descriptions necessary to map the vast complexities of Grand Canyon vegetation.

Others who contributed to our work are acknowledged in the body of the report. Through these collective efforts this document has been designed to serve as the state of the art in the classification and mapping of one of the world's most diverse ecological areas.

R. Roy Johnson
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INTRODUCTION

When C. Hart Merriam visited the Grand Canyon in 1889 during a biological survey of the Coconino Plateau region he wrote of the canyon's vegetation as "a world in itself." Significantly, the map he drew of the "Life Areas " (a concept he later developed into his much debated Life Zones) of the Coconino Plateau and Painted Desert area ended at the canyon rim (Merriam, 1890). The vegetation complexities created by the canyon's extreme topographic relief and intricate mosaic of geomorphic features defeated his efforts at broad classification.

Since that time, the canyon has been the subject of study by a series of botanical investigators, notably Clover and Jotter (1944), Merkle (1962), Phillips (1975), Phillips and Phillips (1979) and Turner and Karpiscak (1980). However, most studies have concentrated upon areas with relatively easy access, such as along the river, the canyon rims and major trails, while the extensive, inaccessible back-country remains largely unknown.

The Grand Canyon is located in an area of unique transition between the cold-climate communities of the Colorado Plateau and Rocky Mountains and the warm-climate communities of the sub-Mogollon Southwest. The canyon itself forms a giant cleft in the southwest corner of the Colorado Plateau, creating a corridor along which species from both regions are brought into close geographic association. The tremendous variety of landforms and geologic features in the canyon results in a diversity of vegetation associations unique for any area of comparable size in North America. Cool shady canyons support forest trees while desert shrubs may thrive on nearby rocky slopes. Expansive bedrock terraces serve as water catchments and allow growth of an unexpected variety of mesic species together with drought-tolerant desert plants. A study of vegetation composition and distribution in an area of such complex intergradation would contribute to the understanding of patterns of plant distribution throughout the Southwest.

The work described here is the first comprehensive description of the vegetation of the Grand Canyon. It was begun in 1977, when the National Park Service contracted with the Applied Remote Sensing Program (ARSP), Office of Arid Lands Studies, University of Arizona, to undertake an investigation designed to result in a set of four vegetation maps for the entire Grand Canyon National Park at a scale of 1:62,500. The function of the maps is for use in making management decisions and for providing a time reference for use in assessing future changes in vegetation resulting from those management decisions, or resulting from other natural or man-caused perturbations.

In addition to the 1:62,500 scale, other basic project specifications called for a vegetation classification system to be modified from the system developed by Brown, Lowe and Pase (1979), and a level of mapping detail commensurate with the complexity of the vegetation and in accordance with the scale of the project (this would result in minimum mapping units ranging in size from 10 acres for highly contrasting vegetation types, particularly wetland areas, to 40 acres or more for less contrasting types).

The production of the vegetation maps for the Grand Canyon called not only for the development of a vegetation classification system, but also for a mapping methodology which could accommodate the arid and semiarid landscape of the park, where vegetation is not visible on medium-scale aerial photography. The mapping

methodology developed for this project involved the use of remote sensing techniques including extensive ground data collection. On account of the nearly inaccessible terrain, an additional input was needed to achieve suitably uniform mapping standards. That input was the use of the correlation of terrain features with vegetation.

Acknowledgments

The authors are most grateful for the cooperation and assistance of the many individuals who contributed in numerous ways in effecting the production of the vegetation maps. Several of our colleagues at the University of Arizona assisted us through field work and by sharing ideas and comments. They include Susan Anderson, Jan Bowers, Tony Burgess, Ken Cole, Charles Lowe, Kim Mortensen, Gary Nabhan, and Wes Pierce. Numerous individuals from the National Park Service were most cooperative and provided valuable assistance to the project. We are especially grateful to the late Merle Stitt, who was the Superintendent at Grand Canyon when the project was initiated, for his support. We appreciate the advice and comments given by Grand Canyon National Park Superintendent Richard Marks. Marv Jensen, Dick McClaren, Tom Caldwell, Jim Huff, John Thomas, Craig Dorman, and others from the River Unit provided considerable logistical support. In addition, Peter Bennett, Bob Euler, Rick Gale, Keith Miller, Dave Ochsner, John Ray, the late John Riffey, Meribeth Riffey, and Jim Walters lent logistical support, provided considerable information on various aspects of the vegetation throughout the park, and commented on drafts of the type descriptions and the resultant maps. Kathy Butterfield provided logistical support and assisted on several field trips. Sue Moran and Rebecca Nelson assisted on some of the field trips. Larry Stevens, Nancy Brian, and Howell Usher from Northern Arizona University provided botanical expertise. Considerable assistance was given by Robin Mouat who was the cartographer for the project and was responsible for originating the base map composites which became the basis for the Eastern and Western sheets. The authors greatly appreciate the considerable efforts of Joan Frederick, Sue Moore, and Emily Whitehead who prepared this manuscript.

Physical Setting

Location

Grand Canyon National Park, located in northwest Arizona, comprises an irregularly-shaped area of approximately 2,200 square miles (Fig.1). It is situated at the southwestern edge of the Colorado Plateau. The park occurs within an area of exceptionally high relief created by incisement of the Colorado River into a surrounding plateau. In the vicinity of the park the river separates the Kaibab Plateau to the north from the somewhat lower Coconino Plateau. Elevations vary widely, ranging from over 9,100 feet (approximately 2,750 meters) on the Kaibab Plateau to a little over 1,000 feet (300 meters) along the river adjacent to Lake Mead.

The extent of the present park boundary encompasses several formerly separate jurisdictions: the former Marble Canyon National Monument in the northeast; the original Grand Canyon National Park including the inner canyon from Nankoweap to Kanab Creek along with the Kaibab and Coconino plateaus in the east central area; the former Grand Canyon National Monument including Toroweap Valley and the Havasupai Joint Use Area; and the inner canyon north of the river from Toroweap Valley downstream to the Grand Wash Cliffs which was formerly part of Lake Mead National Recreation Area.

Climate

The climates of the Grand Canyon are nearly as varied as the geomorphology and vegetation, from the desert of the inner canyon, where freezing temperatures are infrequent and summer temperatures often exceed 100 degrees F, to the North Rim forests, where snow covers the ground several months each year and maximum temperatures never exceed 90 degrees F (Table 1).

The average daily maximum for the warmest month (July) on the South Rim is approximately 85 degrees F (some 7 degrees F cooler on the North Rim). The July monthly mean is approximately 69 degrees F at the South Rim and 62 degrees F at the North Rim. At Phantom Ranch it is 92 degrees F with temperatures over 115 degrees F quite common. The mean monthly temperatures for the coldest month (January) are 29 degrees F at the North Rim, 30 degrees F at the South Rim, and 46 degrees F at Phantom Ranch.

The Grand Canyon is located in an area subject to cyclonic weather disturbances originating in the northeast Pacific during the winter and moist unstable air moving north and northwest from the Gulf of California and Gulf of Mexico in July and August. As a result of these two systems, precipitation has a bimodality of occurrence in winter and summer throughout the region (Fig. 2). The western part of the park tends to have a winter maximum, while the eastern part has a summer maximum. An exception is the Kaibab Plateau which has a winter and not summer maximum. The spring and autumn are generally quite dry throughout the region.

Total precipitation is highest in the higher elevations of the Kaibab Plateau where it reaches an annual average of over 25 inches (with a total average snow fall of over 125 inches; 300 inches maximum recorded), while it averages around 15

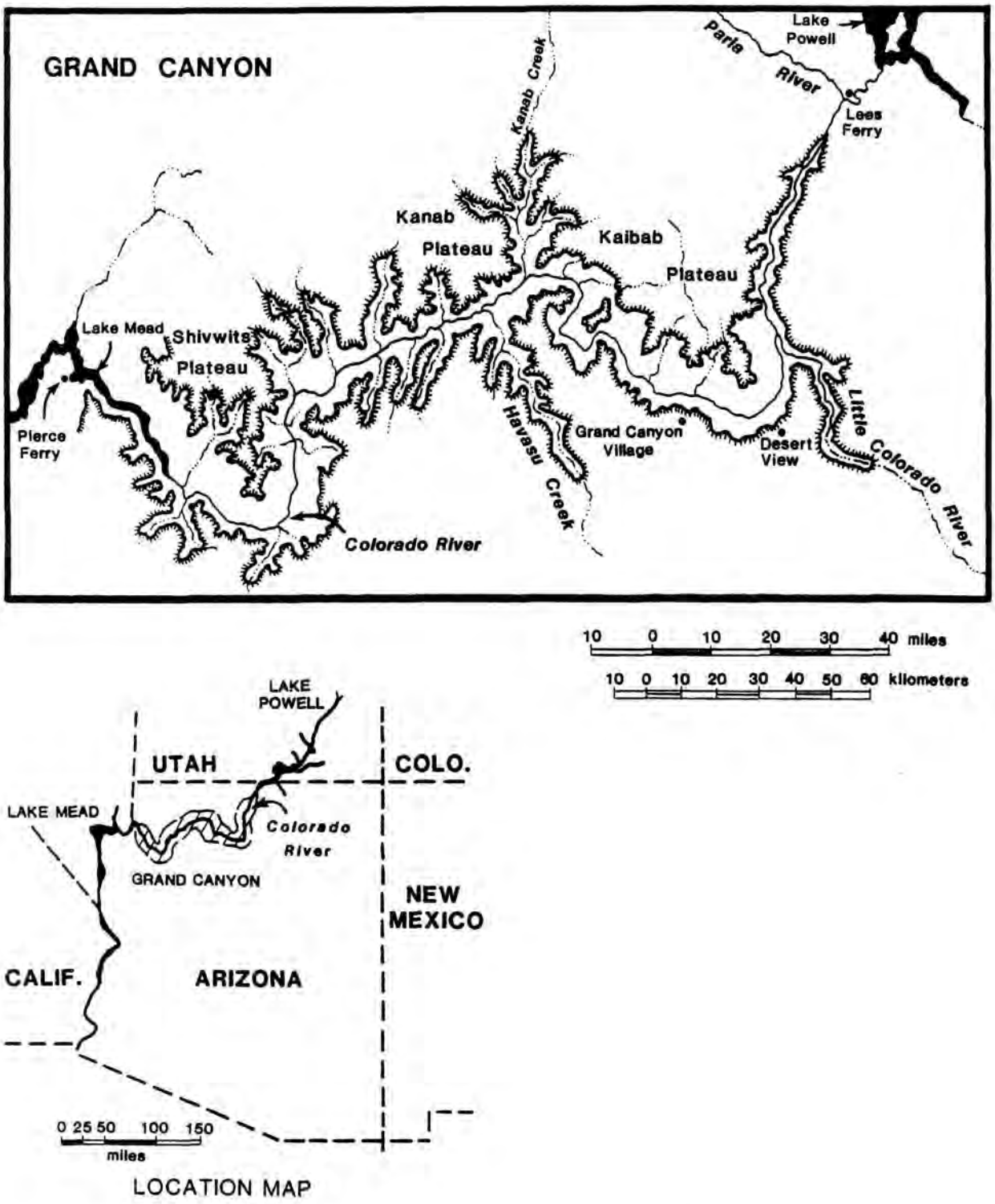


Figure 1. Location of the Grand Canyon and its major geographical landmarks.

TABLE 1. Climate data for the Grand Canyon.[+]

Location	Elevation	Temperature (°F)					Precipitation Inches	
		Extremes		Mean Days/Year				
		High	Low	max above 90	min below 32	max below 32	Mean Rain	Mean Snow
Bright Angel R.S.	8400	91	-25	0	181	28	22.8	128.7
South Rim	6971	98	-16	11	168	13	14.5	69.9
Tuweep	4775	108	0	76	92	0	11.38	9.2
Meadview (Pierce Ferry)	3860	109	6	86	90	0	9.95	6.1
Lees Ferry	3210	115	5	128	77	2	5.81	2.2
Phantom Ranch	2570	120	-9	155	23	0	8.39	0.2

[+]From Sellers and Hill, 1974

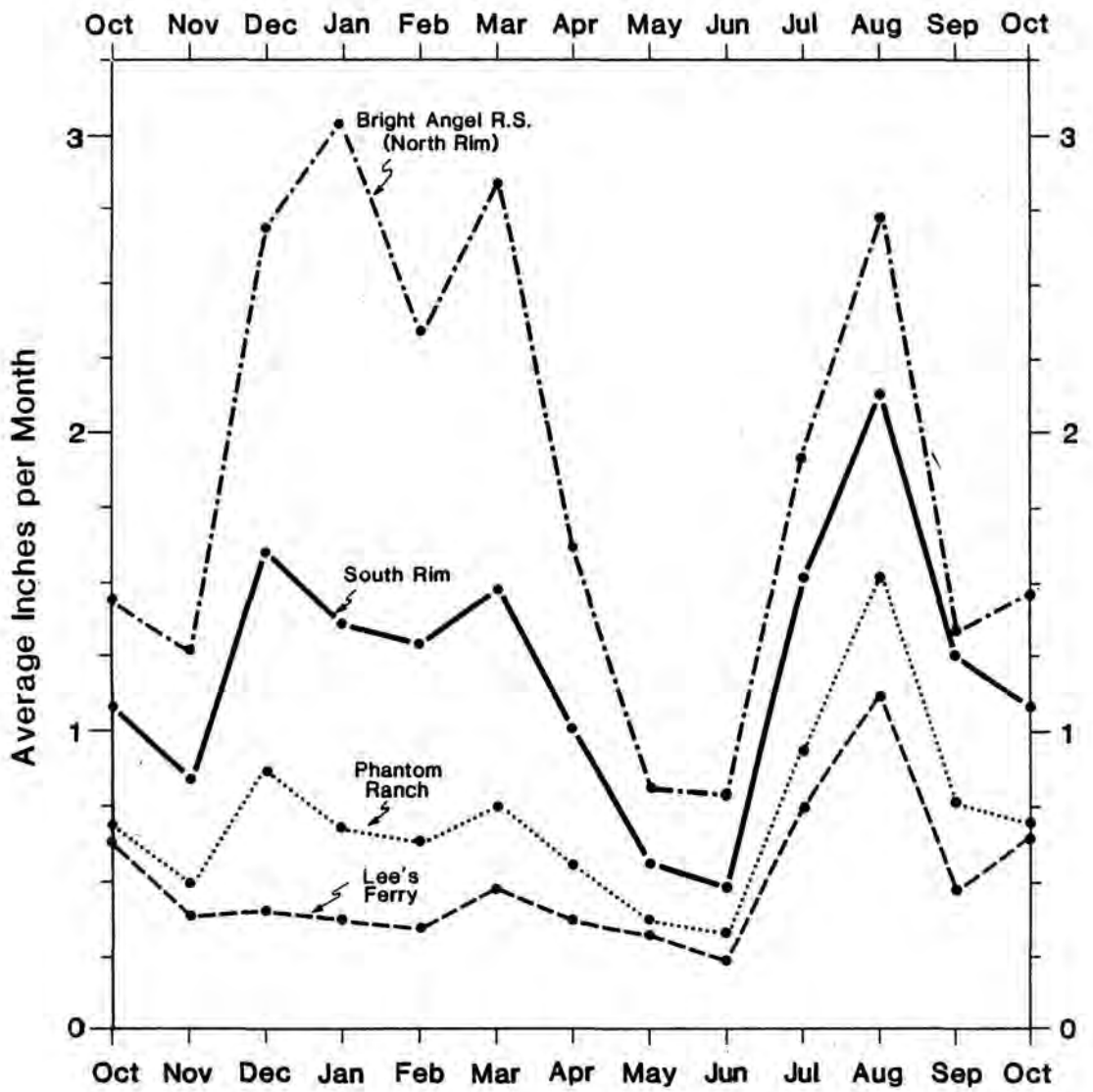


Figure 2. Monthly precipitation in the Grand Canyon region.

inches (with a total average snow fall of approximately 60 inches) on the South Rim. Phantom Ranch, located in the eastern part of the canyon at an elevation of approximately 2,500 feet (750 meters) receives an average annual precipitation of less than 9 inches. Near Lake Mead, precipitation totals are probably less than 6 inches/year.

Geology and Geomorphology

The geologic history of the Grand Canyon area includes rocks which range in age from recent to over 2 billion years. The tremendous sequence in rocks, primarily dating from the Paleozoic and Precambrian eras, is manifest throughout the park as a result of incision into this rock sequence by the Colorado River. The unique and spectacular scenery of the Grand Canyon is due to nearly a mile of vertical incision by the Colorado River through alternating units of resistant and non-resistant rocks.

The oldest rocks of the Grand Canyon, derived from the early Precambrian, consist chiefly of granites, gneisses, and schists. These rock types are well exposed in the inner gorge, especially between Hance Rapids and Elves Chasm (Babcock, Brown, and Clark, 1976). Typical lithologies include the Vishnu Schist and Zoroaster Granite. Landforms developed upon these rocks consist of steep canyon walls with little or no soil developed upon them.

A long period of time followed the formation of these earliest rocks. Mountains were eroded into more gentle topography during the long period of subaerial exposure. During the later Precambrian (approximately 1 billion years ago), sedimentary formations together with some volcanic flows were laid down. These rock units are best observed in the Upper Granite Gorge and in the Nankoweap area. Powell named these rocks the Grand Canyon Series, now renamed the Grand Canyon Supergroup (Ford and Breed, 1976).

The younger Precambrian rocks are subdivided into two groups: Unkar and Chuar. The Unkar Group consist primarily of the Bass Limestone, Hakatai Shale, Shinumo Quartzite, Dox Sandstone, and Cardenas Lavas.

The Nankoweap Sandstone was deposited upon the Cardenas Lava. The later Chuar Group is comprised of the Galeros and Kwagunt Formation which consists of sandstones, shales and limestones. The youngest member of the Chuar Group is the Sixtymile Formation which is predominantly breccia and sandstone.

The entire Grand Canyon Supergroup has been tilted 10-15 degrees. A thickness of approximately 13,000 feet has been observed in these rocks. Landforms typically consist of gently rolling hills, especially in the Nankoweap area and below Desert View. This is due primarily to the very low shear strength and rapid erosion in the Grand Canyon Supergroup. The vegetation response to these parent materials and their resultant landforms is a very depauperate open vegetation formation.

A great erosional period followed the deposition of the Grand Canyon Supergroup. This erosional period is seen as the Great Unconformity between those earlier rocks and the later Paleozoic sediments which followed by approximately 500 million years.

The nearly horizontal sedimentary rocks comprising most of the Grand Canyon and the adjacent plateaus were deposited during the Paleozoic Age. Landforms developed upon these rocks are typically a result of their resistance to erosion. The more resistant rocks such as the Redwall Limestone are cliff-formers, while the less resistant rocks such as the Bright Angel Shale form benches and gently rolling terrain.

The sequence of rocks laid down during the Paleozoic includes the Tapeats Sandstone, Bright Angel Shale and Muav Limestone which comprise the Cambrian Tonto Group. An unconformity exists between the Cambrian and Devonian Ages. The Devonian is primarily represented by the Temple Butte Limestone. The prominent Redwall Limestone is Mississippian in age and one of the most spectacular formations in the canyon. It is highly cavernous and fossiliferous. Deposition of the Supai Formation followed during the Pennsylvanian. The Supai consists of numerous low cliffs and benches having a step-like appearance.

The Hermit Shale was deposited on top of the Supai by freshwater streams during the Permian. The Permian Coconino sandstone overlies the Hermit Shale. It basically consists of a series of continuous windblown dunes. A sea covered the Coconino dunes and deposited the Toroweap and Kaibab Limestones. The latter covers most of the Plateau surfaces adjacent to the canyon.

A remnant of Triassic rocks from the Mesozoic era occurs near Desert View where Cedar Mountain is composed of Moenkopi sandstones and shales and topped by the Shinarump conglomerate.

Cenozoic rocks are represented in several places in the Grand Canyon by lava flows and volcanic intrusions. These are well expressed in the western part of the canyon near Toroweap Valley where Lava Falls, for example, derives its name from the volcanics.

Recent deposits include slumps, rock falls, landslide deposits and alluvial deposits. The landslides and rock falls often form broad coalescing talus slopes covering hundreds of hectares in extent. They are found throughout the canyon but are best developed in areas of less-resistant rock such as the Hermit and Bright Angel Shales. The vegetation types developed upon these unconsolidated parent materials frequently differ from those types developed on adjacent residual soils. Decreased slope stability and variations in soil moisture may account for these changes.

The occurrence of the Grand Canyon in an area of high elevations compared with surrounding terrain has been the subject of controversy for over a hundred years. The principal theories involve antecedence and stream capture and reversal.

The former theory holds that the Colorado River flowed near its present course and maintained its position during the Kaibab uplift. The other principal theory suggests that the former Colorado River flowed south maintaining its course in the approximate vicinity of Marble Canyon but flowed southeast through what is now the Little Colorado River Gorge. Perhaps 20 million years ago, a small stream flowing on the west side of the Kaibab uplift began headward erosion. Perhaps 10 million years ago it met the Colorado River near Cape Solitude and having a steeper gradient, captured that larger system. The Colorado would then have reversed its flow into a southerly and westerly direction. Subsequent erosion resulted in the river attaining its present course.

Both theories, especially the latter, allow for an isostatic adjustment or rebound which would result from the loss of weight of a tremendous volume of rock from the eastern portions of the canyon. The surrounding plateaus could have risen by an additional increment by this adjustment thus resulting in the river flowing through the highest regional terrain.

Regional Affinities of Vegetation - Previous Work

Most of the major biotic communities of Arizona are represented in Grand Canyon National Park either as entire species assemblages or simply as individual characteristic species. The major communities represented are Rocky Mountain forest, Great Basin desertscrub and woodland, chaparral, mountain and desert grassland, Mohave desertscrub and Sonoran desertscrub (the latter only by characteristic species). Previous investigators in the park have generally restricted their studies to only one or two of these communities. The following review summarizes the published information about the park's vegetation and discusses how those observations fit within the regional context of the surrounding major biogeographic regions.

Forests and Woodlands

Coniferous forest and woodland plants of the Grand Canyon belong to the Rocky Mountain flora. This floristic region extends from northern Alberta to the Sierra Madre Range in northern Mexico; and from the Black Hills of South Dakota westward to the Cascades and eastern foothills of the Sierra Nevada Range in California (Daubenmire, 1943). All of the five Rocky Mountain vegetation zones described by Daubenmire: Spruce-Fir, Douglas Fir, Ponderosa Pine, Pinyon-Juniper and Oak-Mountain Mahogany, are represented at the Grand Canyon. The Grand Canyon flora is most closely related to the Wasatch Mountains of Utah and the high elevation plateaus connecting these mountains with the Grand Canyon (Cronquist et al.,1972). A greater number of unique species are located in the Southern Zone of the Rocky Mountain region than in other parts of the region (Daubenmire, 1943) of which this area is a part.

Spruce-Fir vegetation is most widely distributed in the northern Rocky Mountains. In the southern part of its range it is represented in the highest elevation forests (between 9,500 feet and timberline) of New Mexico and Arizona (Merkle, 1954; Dye and Moir, 1977; Moir and Ludwig, 1979; Layser and Schubert, 1979). At the southern distribution of these Spruce-Fir forests the geographic extent is greatly reduced - "occupying less than 0.5% of Arizona and about 2% of New Mexico" (Layser and Schubert, 1979). The highest area on the North Rim of the Grand Canyon, called Spruce-Fir by Merkle (1954), occurs above 8,700 feet and includes blue spruce (*Picea engelmannii*), fir (*Abies lasiocarpa*), white fir (*Abies concolor*), ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menziesii*). Rasmussen (1941) refers to the same area as mixed coniferous forest.

Merkle (1962) describes a lower elevation association of white fir (*Abies concolor*) and ponderosa pine (*Pinus ponderosa*) which occurs with aspen (*Populus tremuloides*) and Douglas fir (*Pseudotsuga menziesii*) and ranges from 8,250 feet to 8,700 feet on the North Rim. This area is also included in Rasmussen's (1941) mixed coniferous forest. Merkle's Spruce-Fir forest and Rasmussen's mixed coniferous forest both correspond to the Douglas Fir-White Fir-Blue Spruce zone of the

Intermountain flora, occurring from 8,000-10,000 feet (Cronquist et al., 1972). Spruce-Fir forest as described by Cronquist (1972) is found only on steep north-facing drainage slopes on the Kaibab Plateau (Dye and Moir, 1977; Layser and Schubert, 1979).

The greatest development of ponderosa pine (*Pinus ponderosa*) forests in the Intermountain region is reached on the Kaibab Plateau between elevations 6,500-8,500 feet (Cronquist et al., 1972). The ponderosa pine vegetation type was described by Merkle as occurring between 7,000-7,400 feet, mixing with pinyon (*Pinus edulis*), juniper (*Juniperus osteosperma*) and big sagebrush (*Artemisia tridentata*) at lower elevations and at higher elevations with white fir (*Abies concolor*) and aspen (*Populus tremuloides*). Rasmussen (1941) and Halvorson (1972) also reported on this vegetation. This zone is distributed throughout the western U.S. from British Columbia and the Black Hills of South Dakota to the Mexican boundary (Society of American Foresters, 1964).

Pinyon (*Pinus edulis*) and juniper (*Juniperus* spp.) vegetation is found at the Grand Canyon on lower elevation plateaus below 6,200 feet (Merkle, 1952). Common associates are big sagebrush (*Artemisia tridentata*), Mormon tea (*Ephedra viridis*), snakeweed (*Gutierrezia sarothrae*) and banana yucca (*Yucca baccata*) (Jameson et al. 1962: Schmutz et al., 1967). The range of pinyon-juniper covers the western slope of the Rocky Mountain area from Northern Mexico to the Snake River in Idaho (Daubenmire, 1943). The primary states in which the zone is common are southern Colorado, New Mexico, Utah, Nevada, Arizona and California (Society of American Foresters, 1964). Cronquist et al (1972) note that the Pinyon-Juniper Zone "occupies more area in the Intermountain region than all the other forest types combined." It extends into the sagebrush zone at lower elevations, and is replaced by pure stands of pinyon or ponderosa pine at the higher elevations. The floristics and distribution of pinyon-juniper in the Great Basin have been studied by Tueller et al. (1979).

Desertscrub

The Grand Canyon is situated in a region of transition between three of the four major desert regions of North America. To the south along the valley of the lower Colorado River the Sonoran Desert is characterized by a two-season rainfall regime and absence of freezing temperatures. To the west the Mohave Desert has winter rains and frequent freezing temperatures. To the north the Great Basin Desert also receives winter rains, although more than the Mohave, and it is subject to long, severe winter freezes.

The differing climates of these regions determine the floristic composition of each (Beatley, 1975). The frequency and intensity of freezing weather is the primary determinant of vegetation diversity among these desertscrub formations. Great Basin desertscrub, which experiences the longest, most extreme freezing weather, generally has the lowest diversity of the three, both in species and growth forms. Mohave desertscrub often has higher local species diversity, but relatively simple physiognomy dominated by shrubs. Of the three, Sonoran desertscrub is the most diverse, both in species and variety of growth-forms (Shreve, 1964).

Within the park, Great Basin desertscrub has been described from Boysag Point (Schmutz et al., 1967) and Fishtail Mesa (Jameson et al., 1962). The vegetation described by these authors is dominated by big sagebrush (*Artemisia*

tridentata) rabbitbrush *(Chrysothamnus* spp.), Mormon tea (*Ephedra* spp.) and a variety of perennial grasses such as blue grama *(Bouteloua gracilis),* Indian ricegrass *(Oryzopsis hymenoides)* and needle-grasses *(Stipa* spp.). These associations are typical of extensive sagebrush-dominated stands of the Great Basin (Shreve, 1942).

Desert vegetation of the inner canyon has been described in both the western part of the park (Phillips, 1975; Van Devender and Mead, 1976) and the eastern part (Cole, 1981). The species composition of the inner canyon is a mixture of Mohave Desert species, such as turpentine broom (*Thamnosma montana*), bladder sage (*Salazaria mexicana*), rabbitbrush (*Chrysothamnus* spp.), blackbrush (*Coleogyne ramosissima*) and others, as well as frost-sensitive species more characteristic of the Sonoran Desert, such as brittle bush (*Encelia farinosa*), catclaw acacia (*Acacia greggii*) and ocotillo (*Fouquieria splendens*). The occurrence of frost-sensitive species decreases upstream from the Grand Wash Cliffs, where the diversity of warm-desert species in the park is at its peak (Phillips and Phillips, 1979).

Riparian Woodland and Scrub

Riparian woodland and scrub occurs in suitable environs throughout the Southwest. Its presence at elevations below 6000 feet often contrasts sharply with the adjacent arid and semiarid upland landscape. Riparian vegetation occurs in areas where soil moisture is sufficiently high to support plant communities more mesic than the surrounding drier uplands. These riparian wetland communities may be found growing on the banks of permanently flowing streams, at large springs, on the banks of montane lakes or playas (dry lake beds), or along desert arroyos.

Riparian woodlands (or forest) characterized by cottonwood-willow associations are primarily restricted to the larger perennial streams and drainages of the Colorado Plateau region of northern Arizona. The great biological importance and floristic diversity of these cottonwood-willow riparian forests is disproportionate to their limited total area. The distribution and composition of riparian forests within the region, outside of Grand Canyon, are described by Woodbury and Russell (1945), Behle et al (1958), Woodbury (1959), Woodbury et al (1959), Bradfield (1974), and Irvine and West (1979).

Riparian scrub usually occurs along ephemeral or intermittent watercourses (such as desert arroyos), or in narrow canyons which are periodically scoured by floods. Riparian scrub communities are characterized by a broad continuum of vegetative associations that range from mesic vegetation types to xeric growth along desert arroyos (Brown et al, 1980). These arroyos often contain water only one day or less each year and the resulting vegetation is commonly composed of a mixture of facultative riparian species and upland species. This is in contrast to mesic species which are generally absent from the surrounding uplands. Woodbury and Russell (1945), Behle et al (1958), Woodbury et al (1959), Woodbury (1959), Bradley and Deacon (1967) and Bradfield (1974) describe riparian scrub (or "desert riparian") within the region. While the appearance of riparian scrub is less dramatic than riparian forest or woodland, this is nevertheless a unique, highly diverse vegetative association. Upland species occurring in these xeric riparian situations often occur in greater densities, as more robust individuals, or both.

Riparian forest or woodland associated with large spring systems ("spring riparian" of Bradley and Deacon, 1967) are rare in northern Arizona. Grand Canyon and Oak Creek Canyon are the two places where these uncommon, localized and

highly diverse riparian systems occur. Woodbury (1959) describes the riparian vegetation associated with smaller springs in the Glen Canyon area.

Clover and Jotter (1944) were the first to describe a portion of the riparian vegetation occurring along the Colorado River and its tributaries within the Grand Canyon. Upstream construction of Glen Canyon Dam in 1963 greatly altered riparian vegetation along the Colorado River, by reducing the peak annual flow and allowing sand bars along the river to stabilize. This new habitat has been colonized primarily by introduced species. The development of a "new" riparian zone composed partly of exotic plants, such as saltcedar (*Tamarix chinensis*), camelthorn (*Alhagi camelorum*) and others, has been documented by Dolan et al. (1974), Carothers and Aitchison (1976), Johnson (1977), Carothers et al. (1979), and Turner and Karpiscak (1980). Phillips et al. (1977) mapped the riparian vegetation along the river.

Side canyons throughout the park with perennial water support riparian vegetation characterized by cottonwood (*Populus fremontii*) and willow (*Salix* spp.), which is generally very similar to that found in similar situations throughout northern Arizona (Phillips and Phillips, 1979). However, a few of the large karstic springs such as Roaring Spring and Thunder River support floras which are unusually diverse and contain relatively uncommon species such as scarlet sumac (*Rhus glabra*), water birch (*Betula occidentalis*), red-osier dogwood (*Cornus stolonifera*), Knowlton hop-horn bean (*Ostrya knowltoni*), and *Ceanothus martini* (Phillips et al., 1979).

METHODS

The methods used to produce the vegetation map were in part developed by ARSP (Mouat et al., 1981; Warren et al., 1981) and in part adapted by ARSP from techniques developed elsewhere (e.g., Poulton et al., 1971; Johnson et al., 1974; Kuchler, 1977). These techniques involved the development of a vegetation classification and description system and a mapping methodology.

The mapping methodology involved the use of remote sensing techniques combined with field verification. Use of aerial photography permits accurate delineation of image features, such as color, texture, pattern, etc., while field work is necessary to identify those features, which may indicate vegetation, soil, or other natural resource features. In mesic areas where vegetation is relatively dense, vegetation features can be observed directly on the photographs. In more arid areas, where vegetation is sparse, it frequently cannot be directly observed on photos of the scale used for this project. Much of the Grand Canyon falls in the latter category. In areas where vegetation features cannot be observed directly on aerial photography, vegetation distribution must be inferred from analysis of terrain features. Depending upon the desired level of mapping detail, terrain-analysis has application to mesic as well as xeric vegetation. The essential prerequisite for accurate mapping by terrain analysis is thorough documentation of vegetation/terrain relationships derived from extensive field sampling.

The several steps involved in producing final maps fall into three major phases as outlined here:

I. Preliminary Activities.

   A. Aerial photography acquisition.
   B. Review of existing data and literature.
   C. Preliminary photo interpretation and image delineation.
   D. Field itinerary planning.

II. Field Work

   A. Sample site selection.
   B. Site documentation.
   C. Two-stage sampling strategy.

III. Final Laboratory Work.

   A. Data analysis/vegetation classification.
   B. Stereoscopic photo analysis and map preparation.
   C. Final map drafting and revision.

For logistic reasons, almost the entire sequence of mapping activities was completed in each of several regions within the park before work was begun in other areas. Thus, a draft map of the Toroweap area was completed before we began work on the North Rim. Final drafting and revision of all maps was done at the end of the project because in some cases vegetation associations on early map drafts were revised on the basis of data gathered toward the end of the project.

Aerial Photography

Aerial photos were used for interpretation of vegetation types and initial delineation, field verification, and final drafting of vegetation types. Photographic coverage for the entire park was obtained, including both existing coverage for some areas and newly acquired photographs where the existing photos were lacking or inappropriate for the requirements of the vegetation mapping methodology. All photography used was of scale 1:24,000, taken with either natural color or color infrared film.

An entire set of the photography is on file at the Resources Management Office of Grand Canyon National Park. A duplicate set of the aerial photography is located at ARSP.

Data sources contracted during the project included two aerial surveys conducted by Aerial Mapping of Phoenix, Arizona, which comprise the greatest area of photographic coverage. An aerial survey conducted in 1978 covered the eastern half of the park, and a survey conducted in 1980 covered the western third of the park. The photography was acquired at a scale of 1:24,000 with a color 9" X 9" format. Standard 60% + forward overlap and 20% + side overlap was obtained in order to ensure complete stereoscopic coverage. Color photography was chosen instead of color infrared photography for the following reason. Most of the Grand Canyon is either arid or semiarid. As such, the bare soil dominates much of the surface. Bare soil is better discriminated on natural color than on color infrared photography. Since soil geomorphologic units correlate well with vegetation types in arid and semiarid areas, color photography was felt to be an ideal data source.

Some areas within the park are covered by moderately dense to dense coniferous forest and mixed deciduous shrub types. In these areas, color infrared photography would have been preferred to natural color. The areas, however, covered less than 20% of the park's area and were also accessible by roads. Thus, increased ground examination could be carried out in those areas to ensure reliability.

Complete sets of existing aerial photography were obtained for the Havasupai Indian Traditional Use Area and for the Monument Area. Color photography of a portion of the canyon flown by Slaymaker Photography in 1977 is on file at ARSP. That photography covered the Havasupai Indian Reservation including the Traditional Use Area and other adjacent Park Service lands. The scale was 1:24,000, and although the color balance was outstanding, the resolution was marginal (shrubs 1 meter in diameter were not visible) and the coverage of Park Service lands was small.

Color infrared photography covering the western portion of the park, scale 1:24,000, was flown for the Bureau of Land Management (BLM) in 1976 for a survey of a large area of BLM lands in northwestern Arizona. The photography was purchased for the monument area only, although the Lake Mead-Shivwits Plateau area is covered by this mission. This area is covered by the Aerial Mapping 1980 photography.

A small gap in photographic coverage for the park occurs in the vicinity of SB Point on the Kanab Plateau. A U-2 color infrared photo of the region was enlarged to a scale 1:30,000 to cover this region. Because the color balance and resolution

were poor, this coverage was supplemented by 35 mm color slides and prints taken from a low-flying aircraft by Warren, Reichhardt and Johnson. The U-2 and 35 mm photos are on file at ARSP.

Preliminary Activities

Preliminary reconnaissance was essential to plan strategies for the more intensive work to follow. Literature on Grand Canyon plant ecology was reviewed to gain an understanding of the broad patterns of plant distribution. Field reconnaissance allowed for greater familiarity with the variety of vegetation types and diversity of terrain to be found at Grand Canyon National Park. It gave us an appreciation for general vegetation/terrain relationships and for spatial variations and distributions within vegetation types. This understanding was essential for the more intensive work which followed.

The training of field personnel was an integral part of the project because several park service employees who were unfamiliar with the mapping methodology assisted with fieldwork. It was essential that field personnel be consistent in their observations and in the manner in which they delineated and later identified vegetation types. Thus, decision criteria, field forms, and oral instruction were provided to ensure this consistency.

Preliminary Photo Interpretation

Before field work was begun, all aerial photos were inspected and field work itineraries were planned on the basis of preliminary photo interpretation. Delineations of probable mapping units were made on the basis of image characteristics such as color, texture, patterns, and other recognizable elements, particularly terrain features. Delineations were made on acetate overlays directly over the photos. Field work was planned so that all of the different image-classes in the region were visited and documented.

Field work served to relate actual vegetation associations with image features delineated on the photographs during preliminary photo-interpretation activities. In some cases, areas on the photos with different image characteristics, for example differences in soil color, represented the same vegetation type and the different preliminary units were combined. In other cases, field work showed that some preliminary mapping units could be further subdivided into identifiable vegetation associations on the basis of more subtle discriminations than were used to perform the preliminary delineations.

In the arid portions of the Grand Canyon, techniques which involved the discrimination of vegetation through terrain correlation were found to be effective. Terrain variables which were interpretable (or were readily obtainable from topographic maps) and which were used to correlate with vegetation included: landform, elevation, slope angle, aspect, surface parent material, and geologic formation.

Sample Site Selection

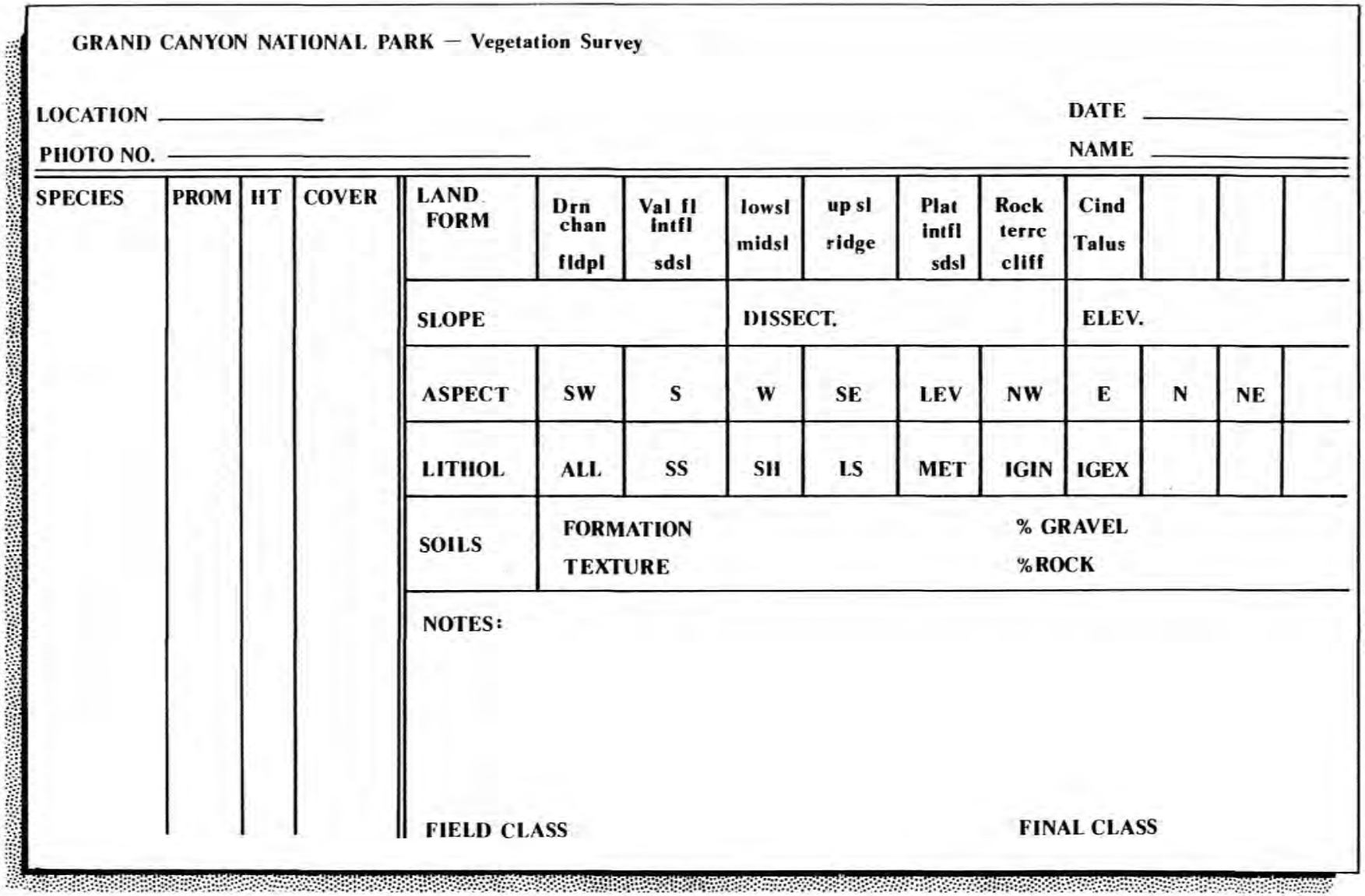
An effort was made to sample homogeneous representative examples of each vegetation type. For example, in a situation where a soil-controlled transition occurs between one type on a terrace and another on an adjacent rocky hillslope, the sample area recorded on one form would not include both the hillslope and the terrace. As a result of terrain-related restrictions, some site samples may cover a larger area than others. For example, a discrete identifiable type may occupy a small hillside next to an extensive blackbrush flat. It may be clearly possible to sample a much larger area in the blackbrush type and still remain within a uniform representative example of the type. Although sampling biases such as these cannot be completely eliminated, standardization of sampling intensity among types was improved by restricting the area sampled to between 1/2 and 1 hectare.

Site Documentation

Field observations were recorded on a standardized field form (Fig. 3). A total of almost 1,500 sites were sampled, all of which were located on topographic base maps and aerial photos for future relocation. Data included a species list usually presented in an alphameric acronym consisting of the first two letters of the genus and species names (e.g., "Pied" indicates *Pinus edulis)* together with estimates of the plant species height, prominence and cover. Prominence values were used to give an indication of the relative importance of each species in a stand. These values are subjectively derived and are included for comparative purposes. Prominence ratings range on a scale from 1 to 5. If one species was clearly dominant, its prominence would be "5". Two or more codominants would be indicated by "4". Highly prominent but subdominant species also received a "4". Species which are common and characteristic of a site would receive a "3". They are readily observed throughout the stand. Occasional species usually having a cover of less than 1% receive a value of "2," and uncommon species which are noticed only after careful examination or which only occur once or twice in a stand are assigned a prominence value of "1." The cover for each species and for the entire vegetation assemblage was estimated at each site and recorded.

Botanical nomenclature followed Lehr (1978). McDougall (1973) was referred to for species identifications and distributions. A few closely related pairs of species were difficult to separate in some circumstances and were treated together in some type descriptions. These include *Artemisia tridentata/A. nova*, *Quercus turbinella/Q. undulata*, *Ephedra viridis/E. nevadensis*, and *Fraxinus anomala/F. cuspidata*.

Several terrain features were recorded on the field form. Their characteristics were standardized and indicated on the form. Those terrain features which were documented for each site include landform, slope angle and aspect, degree of dissection, elevation, general surface lithology and formation, and soil characteristics (surface soil texture as well as percentage of gravel and rock at the surface). Additional comments or notes regarding the physical characteristics of the site were recorded on the form as considered necessary by the observer. The location of each documentation site was made directly on the aerial photograph. A 35 mm color photograph was taken of each vegetation association.



GRAND CANYON NATIONAL PARK — Vegetation Survey

LOCATION _____ DATE _____

PHOTO NO. _____ NAME _____

SPECIES	PROM	HT	COVER	LAND FORM	Drn chan fldpl	Val fl intfl sdsl	lowsl midsl	up sl ridge	Plat intfl sdsl	Rock terrc cliff	Cind Talus			
				SLOPE			DISSECT.				ELEV.			
				ASPECT	SW	S	W	SE	LEV	NW	E	N	NE	
				LITHOL	ALL	SS	SH	LS	MET	IGIN	IGEX			
				SOILS	FORMATION					% GRAVEL				
					TEXTURE					%ROCK				
				NOTES:										
				FIELD CLASS						FINAL CLASS				

Figure 3. Field documentation form used at Grand Canyon National Park.

Two-Stage Sampling Strategy

A two-stage sampling scheme was used which provided detailed information about local distribution of vegetation associations as well as documentation of the predictability of each association over large, inaccessible areas. The method involved first, intense local sampling within limited areas followed by extensive low-intensity sampling between areas of intensive sampling. The first stage documented patterns of distribution and the second stage verified that the patterns were continuous over a large area.

Intensive sampling was generally carried out on foot over a period of several days spent in areas with easy access, such as along roads, trails, and the river. Sample sites were chosen on all topographic situations and at all elevations within the intensive sample area. These intensive data served as the primary source for describing distribution of vegetation associations.

After distribution patterns were determined by intensive sampling, extensive sampling was performed, usually by helicopter, to make certain that the patterns were reliable over large areas. Usually two to four sites were sampled at each helicopter stop. When inconsistencies were observed during the second stage, additional high-intensity sampling was performed in the problem area.

Vegetation Classification

The classification of field data into the final vegetation associations was based on two major considerations. The first was floristic similarity among sites, that is, the number of plant species which were shared between sites. The second is the similarity of terrain features, particularly landforms and soil features, among sites. The preliminary classification was determined by a comparison of presence or absence and relative abundance of plant species among the numerous sample sites. However, the final classification was significantly affected by the consistent occurrence of floristic associations with particular terrain features.

All of the site data were classified manually on the basis of floristic similarity and summarized in tabular form (as described by Shimwell, 1971; and Mueller-Dombois and Ellenberg, 1974). In this manner, the results of numerous field sites can be collated and compared quickly and conveniently (see Table 2). Each column in the data summary table represents one field documentation site and each row indicates one species, with the prominence value for each plant species entered in the columns of the sites in which they occur. Inspection of the summary tables readily shows patterns of association among some plant species and lack of association among others. Those with reliable association patterns are considered to be the characteristic species of the vegetation types which were described in the final classification.

Following preliminary classification based on floristic analysis, the types were re-evaluated on the basis of the photointerpretation of each type. After consideration of the interpretability of each type, preliminary classes may be recombined or divided to form the final types which serve as mapping units. The sample sites in each type were summarized on the basis of distribution and floristics. The number of sites used to document each association ranged from 1 to 95, with larger sample sizes present in associations with wider distribution. In the case of very restricted types, a single sample could represent the entire distribution

Table 2. An example of the tabular method used to summarize field data.

Vegetation type 121.3111 *Picea engelmanii – Abies lasiocarpa*

Regions summarized on this sheet North Rim

Total forms used 23

Aerial Photo and Site Number

Species Name	9-12,3	9-13,1	10-10,1	10-10,2	10-11,1	10-11,2	10-11,3	10-12,1	10-16,1	10-16,2	10-16,3	10-16,4	10-16,5	11-13,3	11-13,7	11-15,1	11-15,3	11-16,2	11-16,3	11-17,3	11-17,6	11-17,8	11-18,2	Total occurrences	Prominence range	Prominence mean	Frequency
	Prominence																										
Picea engelmanii	3	3	4	2	3	4	4	4	4	3	4	5	4	4	4	4	1	4	4	4	2	4	4	23	1-5	3.5	1.0
Abies lasiocarpa	4	4	4	2	4	3	3	4	3		3		4	4	3	2	4	4	2	4	4	4	3	21	2-4	3.4	.9
Populus tremuloides	3	2	3	3	3	4	3		2	4	3	3	2	4	4	3	3	3	2	4	3	4	3	22	2-4	3.0	.9
Juniperus communis	2	2	1				2	2	3	3	3				3	3	3	2		2	3			14	1-3	2.4	.6
Pinus ponderosa				3		2			2	3			3	1	2	2	2		3	1	2	3		13	1-3	2.1	.6
Pseudotsuga menziesii			1	3							3	1				3		1		4				7	1-4	2.2	.3
Abies concolor		2	1	4		3						1					2					3		7	1-4	2.3	.3
Carex spp.	1	3	3	3							3	1	1		2		2		1	2	2			12	1-3	2.0	.5
Robinia neomexicana																						3		1	3	3.0	.1
Pteridium aquilinum									3			1						2						3	1-3	2.0	.1
Berberis repens									3															1	3	3.0	.1
Lupinus spp.									3															1	3	3.0	.1
Lotus utahensis																			1					1	1	1.0	.1
Mimulus spp.																			1					1	1	1.0	.1
Fragaria spp.										2					1									2	2	2.0	.1
Eriogonum spp.										1														1	1	1.0	.1

range of the association. For types covering extensive areas, numerous samples were taken to document the variation within the types. In general, 10 to 15 samples were found to be adequate to document the composition of an association.

Cartography

Four steps were involved in the production of the maps. First, as stated previously, delineations of vegetation types were drawn on clear acetate overlays of the color aerial photographs at a scale of 1:24,000. Second, the mapping units were redrawn at a scale of 1:62,500 on larger acetate overlays of planimetrically accurate topographic base maps. Vegetation type boundaries were revised and corrected on this rough draft. Third, the corrected vegetation types were drafted directly onto a dimensionally stable photo mylar of the topographic base map. The base maps were screened to 60% to reduce the intensity of topographic data and to allow the vegetation mapping lines to stand out. The fourth and final step was the photographic reproduction of the maps onto frosted mylar, a sturdy material which resists dimensional distortion with changes in temperature and humidity. Inexpensive "black-line" paper copies can be made from the photo mylar.

Four maps were produced at a scale of 1:62,500 to cover the park (Fig. 4). The base maps for the East Central and West Central sheets were existing maps acquired from the USGS. The latter map was reduced from the original scale of 1:48,000 to 1:62,500. The base maps for the Eastern and Western sheets are composite maps assembled and photographed from paper copies of individual USGS topographic maps. Because these last two maps are composites, the contour interval varies. An index of the original topographic maps and their respective contour intervals has been provided on the maps.

There are many variations in vegetation structure and floristics within and among the vegetation types. Several techniques were used to account for these variations. Local differences in species composition within a single type are treated in the type descriptions. Variations over larger distances which are too fine to map are indicated by cartographic techniques. Two mapping techniques are used to depict this variation:

(1) Gradients between vegetation types which change gradually from one to another over a distance of one or two kilometers cannot be accurately represented by a solid line. In such cases, a dashed line represents the gradual transition. One example is on the North Rim, where forest types intergrade in response to elevation and related factors.

(2) Two or more vegetation types whose occurrences change repeatedly over small intervals caused by a myriad of factors (including, for example, presence of rock outcrops) and which cannot be mapped separately due to the map scale, may be dealt with cartographically by treating the intermixed types as a complex. In this case, the numerical designators of both types appear in the map unit with a slash separating one type from the other with the more abundant type appearing first. For example, on the West Central Sheet, stands of pinyon-juniper with big sagebrush and cliffrose are distributed throughout the pinyon-juniper woodland, forming a mosaic of the two. This unit is designated as 122.4144/122.4145.

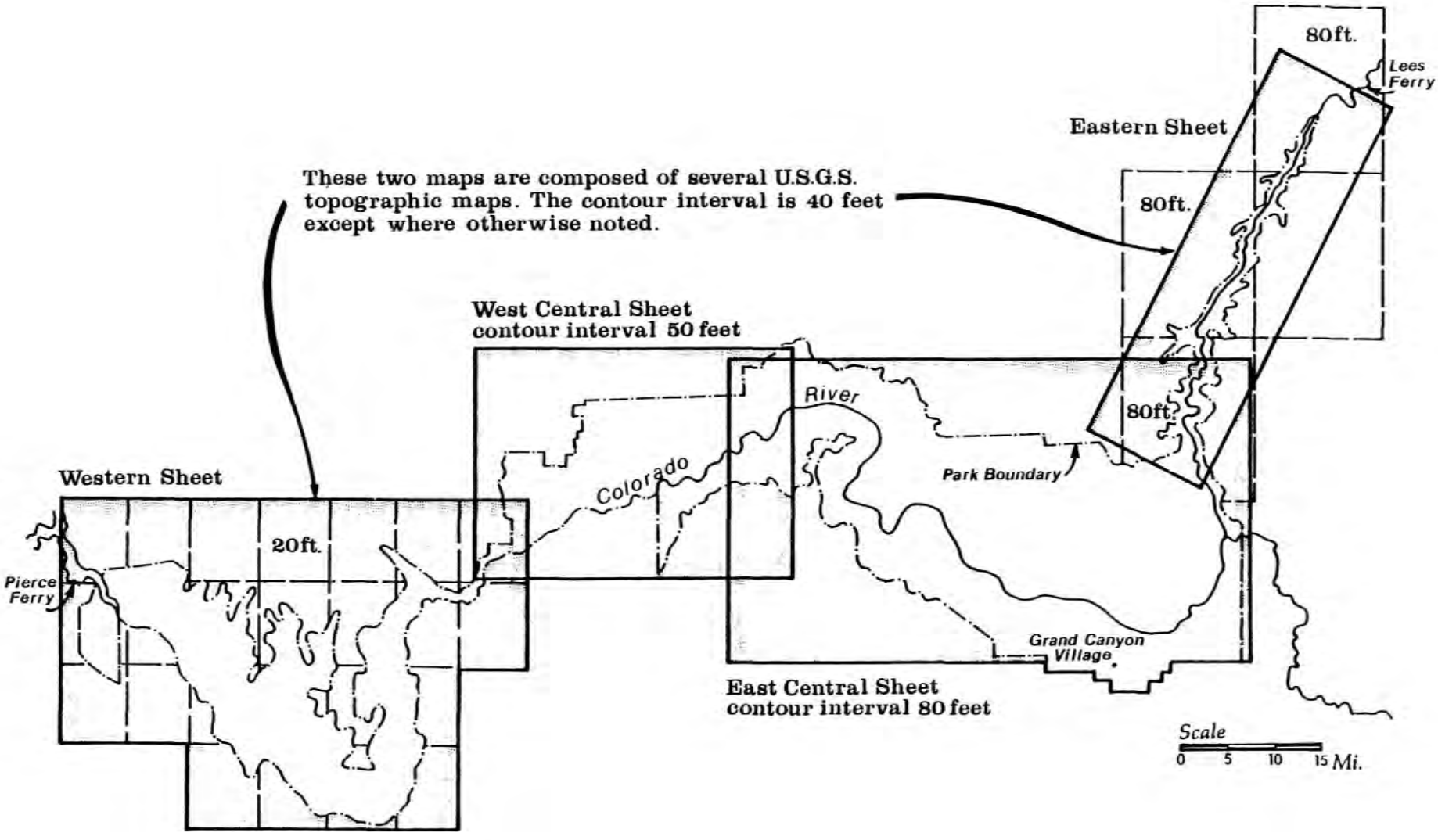


Figure 4. Map of Grand Canyon National Park showing the location of the four 1:62,500 scale map sheets used for this project.

RESULTS

A total of 63 vegetation associations were identified and mapped in the park on the basis of data gathered from nearly 1,500 sample sites. Descriptions of these associations, as well as accounts of general patterns in the major communities, follow here.

Description Format

The format of the vegetation type descriptions includes the type name and three descriptive components: distribution, floristics, and physiognomy. The information provided in the type descriptions allows both the resource manager and the resource scientist to better understand the important attributes of each type. It will also allow for flexibility in considering the type at larger or smaller scales than that (1:62,500) which is displayed on the maps. A summary of the vegetation classification (Table 3) precedes the descriptions.

The vegetation types described were identified based on the hierarchical system of Brown, Lowe and Pase (1979). This system is based on physiognomic and geographic characteristics at lower levels. The classification developed for this project deviates from that one in that the type descriptions at the seventh level are based on field observation and the summarization of data for each vegetation type sampled. In some cases, limitations of mapping scale permitted description and identification only to the fifth or sixth level, for example in high elevation meadows where species composition changes dramatically along local moisture gradients. A standardized classification structure such as this is useful for comparison of work in different areas, but it is important to bear in mind that the final results will depend more heavily on classification procedures than on the classification system.

Distribution

The distribution description of each type includes its geographic range as well as its physiographic and elevational range. Local distribution patterns are also described emphasizing small scale variation in slope aspect and steepness, soil type and other terrain features pertinent to the type. The relation to other types or uniqueness of local situations is also included.

Floristics

The floristic characteristics of the vegetation types, including the plant species present and relative abundance of those species, comprise the primary information by which the types are defined and distinguished from one another. The floristic components of each type are presented as "characteristic" species or "associated" species and are characterized by average prominence (range and mean) and frequency values (described previously). The frequency index, expressed in terms of the percent of samples in an association in which a species occurs, has been used to illustrate the constancy of species within an association.

Those species which occur in more than 50% of the sites sampled and have a prominence of at least 2.0 are classified as "characteristic" species. The name of

the type is based on the three (sometimes two or four) most characteristic species of the type. The plants classified as "associated" species may occasionally be fairly abundant, but they are generally irregular in occurrence and are not reliable indicators for defining a type. Species occurring in less than 20 percent of the sites sampled in an association were considered to be "occasional" species. The list of species in this section should not be treated as a complete flora of each vegetation type because field sampling was performed over a limited area and during a limited time within each type.

Physiognomy

The primary structural features include: a) dominant plant growth form; b) leaf characteristics, such as size and phenology and morphology (i.e., deciduous, evergreen, sclerophyllous) for the dominant species; c) community structure or arrangement (spacing and height of dominants or codominants); d) description of lower synusia and ground cover (including phenology where appropriate); and e) estimated total percent cover.

TABLE 3. Vegetation Associations of Grand Canyon National Park.[+]

120 Forest and Woodland Formation

121	Boreal Forests and Woodlands	
	121.3	Rocky Mountain Subalpine Conifer Forest and Woodland
	121.31	Engelmann Spruce - Alpine Fir Series
	121.311	*Picea engelmannii - Abies lasiocarpa* Association
	*121.3111	*Picea engelmannii - Abies lasiocarpa - Populus tremuloides*
	121.317	*Picea engelmannii* - Mixed Conifer Association
	*121.3171	*Picea engelmannii - Abies concolor - Pinus ponderosa*
	*121.3172	*Populus tremuloides - Pinus ponderosa - Picea engelmannii*
122	Cold Temperate Forests and Woodlands	
	122.3	Rocky Mountain Montane Conifer Forest
	122.31	Douglas Fir - White Fir Series
	122.312	*Pseudotsuga menziesii - Abies concolor* Association
	*122.3121	*Pseudotsuga menziesii - Abies concolor - Robinia neomexicana*
	122.32	Pine Series
	122.321	*Pinus ponderosa* Association
	*122.3211	*Pinus ponderosa - Populus tremuloides - Picea engelmannii*
	*122.3212	*Pinus ponderosa* - forbs
	122.322	*Pinus ponderosa* - Mixed Conifer Association
	*122.3221	*Pinus ponderosa - Populus tremuloides - Abies concolor - Pseudotsuga menziesii*
	*122.3222	*Populus tremuloides - Pinus ponderosa - Picea engelmannii*
	122.323	*Pinus ponderosa - Quercus gambelii* Association
	*122.3231	*Pinus ponderosa - Robinia neomexicana - Quercus gambelii*
	*122.3232	*Pinus ponderosa - Pinus edulis - Cowania mexicana - Artemisia nova*
	*122.3233	*Pinus ponderosa - Pinus edulis - Quercus gambelii - Juniperus osteosperma*
	*122.3234	*Pinus ponderosa - Quercus gambelii - Artemisia tridentata*
	122.326	*Pinus ponderosa - Picea engelmannii* Association
	*122.3261	*Pinus ponderosa - Picea engelmannii - Populus tremuloides*
	122.327	*Pinus ponderosa - Abies concolor* Association
	*122.3271	*Pinus ponderosa - Abies concolor - Populus tremuloides - Picea engelmannii*
	*122.3272	*Abies concolor - Pinus ponderosa - Populus tremuloides - Poa pratensis*
	*122.3273	*Pinus ponderosa - Abies concolor - Populus tremuloides - Robinia neomexicana*
	*122.3274	*Pinus ponderosa - Abies concolor - Quercus gambelii - Robinia neomexicana*

[+] Adapted from the system of Brown, Lowe and Pase (1979).

* Vegetation types used as mapping units.

TABLE 3. (continued)

122.4	Great Basin Conifer Woodland
122.41	Pinyon-Juniper Series
122.414	*Pinus edulis - Juniperus osteosperma* Association
*122.4141	*Pinus edulis - Juniperus osteosperma - Quercus turbinella - Cercocarpus intricatus*
*122.4142	*Juniperus osteosperma - Pinus edulis - Ephedra viridis - Quercus turbinella*
*122.4143	*Juniperus osteosperma - Pinus edulis - Artemisia tridentata - Ephedra viridis*
*122.4144	*Juniperus osteosperma - Artemisia tridentata - Pinus edulis - Yucca baccata*
*122.4145	*Pinus edulis - Juniperus osteosperma - Artemisia tridentata - Cowania mexicana*
*122.4146	*Pinus edulis - Quercus turbinella - Arctostaphylos pungens - Juniperus osteosperma*
*122.4147	*Coleogyne ramosissima - Pinus edulis - Juniperus osteosperma - Ephedra viridis*
*122.4148	*Pinus edulis - Amelanchier utahensis - Quercus gambelii - Juniperus osteosperma*
*122.4149	*Pinus edulis - Juniperus osteosperma - Poa pratensis - Yucca baccata*
*122.41410	*Mortonia scabrella - Pinus edulis - Quercus gambelii*
*122.41411	*Juniperus osteosperma - Pinus edulis - Ephedra viridis - Glossopetalon nevadensis*
122.7	Rocky Mountain Deciduous Forest
122.71	Aspen Series
122.711	*Populus tremuloides* Association
*122.7111	*Populus tremuloides - Pinus ponderosa*

130 Scrubland Formation

133	Warm Temperate Scrubland	
	133.3	Interior Chaparral
	133.31	Scrub Oak Series
	133 311	*Quercus turbinella* Association
	*133.3111	*Quercus turbinella - Arctostaphylos pungens*

140 Grassland Formation

142	Cold Temperate Grasslands	
	142.2	Great Basin Shrub-Grassland
	142.25	Great Basin Shrub-Grassland Disclimax Series
	142 251	*Hilaria rigida* Association
	*142.2511	*Hilaria rigida - Bromus tectorum - Gutierrezia sarothrae*
	142.4	Rocky Mountain Montane Grassland
	142.41	Mixed Meadow Series
	*142.411	Mixed Grass-Forb Association
143	Warm Temperate Grasslands	
	143.1	Scrub-Grassland (Semidesert Grassland)
	143.11	Grama Grass-Scrub Series
	143.113	*Bouteloua eriopoda* - Mixed Grass-Mixed Scrub Association
	*143.1131	*Bouteloua eriopoda - Gutierrezia sarothrae - Eurotia lanata - Atriplex canescens*

TABLE 3. (continued)

150 Desertland Formation

152 Cold Temperate Desertlands
- 152.1 Great Basin Desertscrub
- 152.11 Sagebrush Series
- 152.111 *Artemisia tridentata* Association
- *152.1111 *Artemisia tridentata - Gutierrezia sarothrae - Bouteloua gracilis*
- *152.1112 *Artemisia tridentata - Juniperus osteosperma - Pinus edulis*
- 152.112 *Artemisia tridentata* - Mixed Desertscrub Association
- *152.1121 *Artemisia tridentata - Gutierrezia sarothrae - Ephedra viridis*
- 152.114 *Artemisia* sp. - *Atriplex* sp. Association
- *152.1141 *Artemisia tridentata - Atriplex canescens - Ephedra viridis*
- *152.1142 *Artemisia nova - Atriplex canescens - Ephedra viridis*
- 152.13 Blackbrush Series
- 151.131 *Coleogyne ramosissima* Association
- *152.1311 *Coleogyne ramosissima - Ephedra viridis - Yucca baccata*
- 152.15 Winterfat Series
- 152.153 *Eurotia lanata - Atriplex* sp. Association
- *152.1531 *Eurotia lanata - Atriplex canescens - Ephedra viridis*
- 152.16 Mixed Scrub Series
- 152.162 Mixed Scrub Association
- *152.1621 *Quercus turbinella - Gutierrezia sarothrae - Nolina microcarpa - Coleogyne ramosissima*
- 152.17 Saltbush Series
- 152.172 *Atriplex canescens* Association
- *152.1721 *Atriplex canescens - Artemisia tridentata - Gutierrezia sarothrae*
- *152.1722 *Atriplex canescens - Yucca baccata - Gutierrezia sarothrae*
- *152.1723 *Atriplex canescens - Eurotia lanata - Ephedra viridis*

153 Warm Temperate Desertlands
- 153.1 Mohave Desertscrub
- 153.11 Creosotebush Series
- 153.111 *Larrea tridentata* Association
- *153.1111 *Larrea tridentata - Opuntia basilaris - Fouquieria splendens*
- 153.112 *Larrea tridentata - Ambrosia dumosa* Association
- *153.1121 *Larrea tridentata - Ambrosia dumosa - Ephedra* spp.
- 153.12 Blackbrush Series
- 153.121 *Coleogyne ramosissima* Association
- *153.1211 *Coleogyne ramosissima - Ephedra* spp. *- Yucca baccata*
- *153.1212 *Coleogyne ramosissima - Yucca brevifolia - Yucca baccata*
- *153.1213 *Coleogyne ramosissima - Yucca baccata - Cowania mexicana - Agave utahensis*
- 153.17 Saltbush Series
- 153.172 *Atriplex hymenelytra* Association
- *153.1721 *Atriplex hymenelytra - Larrea tridentata - Ambrosia dumosa*
- 153.173 *Atriplex canescens* Association
- *153.1731 *Atriplex canescens - Opuntia erinacea - Prosopis glandulosa*

TABLE 3. (continued)

153.174	*Atriplex confertifolia* Association
*153.1741	*Atriplex confertifolia - Ephedra nevadensis - Opuntia basilaris*
153.18	Globe mallow Series
153.181	*Sphaeralcea ambigua* Association
*153.1811	*Sphaeralcea ambigua - Ephedra nevadensis - Larrea tridentata*
*153.1812	*Sphaeralcea ambigua - Dalea fremontii - Fouquieria splendens*
153.19	Brittlebush Series
153.191	*Encelia farinosa* Association
*153.1911	*Encelia farinosa - Larrea tridentata - Ferocactus acanthodes*
*153.1912	*Encelia farinosa - Ephedra* spp. *- Acacia greggii*
153.110	Mormon Tea Series
153.1101	*Gutierrezia sarothrae - Ephedra viridis* Association
*153.11011	*Gutierrezia sarothrae - Ephedra viridis - Agave utahensis*
*153.11012	*Ephedra* spp. *Salvia carnosa - Lycium andersonii*
*153.11013	*Ambrosia dumosa - Ephedra nevadensis - Ferocactus acanthodes*
*153.11014	*Ephedra viridis - Gutierrezia sarothrae - Lycium andersonii*
*153.11016	*Ephedra viridis - Hilaria rigida - Sphaeralcea ambigua*
*153.11017	*Ephedra nevadensis - Coleogyne ramosissima - Larrea tridentata*

220 Wetland Forest Formation

223	Warm Temperate Swamp and Riparian Forests	
	223.2	Interior Southwestern Riparian Deciduous Forest and Woodland
	223.21	Cottonwood - Willow Series
	223.212	*Populus fremontii* Association
	*223.2121	*Populus fremontii - Brickellia longifolia - Acacia greggii*

250 Strand Formation

253	Warm Temperate Strands	
	253.4	Mohavian Interior Strand
	253.42	Mixed Scrub Series
	253.422	*Acacia greggii* Association
	*253.4221	*Acacia greggii - Baccharis* spp. *- Fallugia paradoxa*

Forests

Coniferous forests are found only on the high plateau regions of the park which include the Kaibab Plateau (North Rim), Powell Plateau, Coconino Plateau (South Rim) and Uinkaret Plateau (Mt. Emma). The greatest diversity of forest types occurs on the Kaibab Plateau which reaches an elevation of approximately 9,150 feet (2,790 meters) at the highest point in the park.

Four major coniferous forest communities are distributed in broad elevational bands across the North Rim. At the highest elevations, from approximately 8,800 to 9,150 feet, is a mixed coniferous forest dominated by *Picea engelmannii, Abies concolor* and *Pinus ponderosa* with *Pseudotsuga menziesii* and *Abies lasiocarpa* as common associates. From roughly 8,400 to 8,800 feet the next major community is dominated by *Pinus ponderosa* and *Abies concolor* with *Pseudotsuga menziesii* and *Picea engelmannii* as subordinate species. At lower elevations the diversity of tree species decreases rapidly. The third major forest community, occurring from approximately 8,000 to 8,400 feet, is dominated by *Pinus ponderosa* and *Abies concolor* with only infrequent occurrence of other tree species. The fourth major community, which forms a broad belt extending from approximately 8,000 feet to the plateau rim at approximately 7,600 feet, is composed of *Pinus ponderosa* as the single dominant in open parklands or with an understory of deciduous trees and shrubs. The one abundant deciduous tree of the plateau, *Populus tremuloides*, is common throughout all of these forest communities, occasionally forming stands with few coniferous trees present. The description of stands of *P. tremuloides* (122.7111), which are apparently non-successional, appears out of numerical order because it has been grouped with other forest types.

A mosaic of vegetation associations is found within the general pattern of the four bands of forest communities. A series of small valleys cuts across the elevational pattern described above. Within each valley the vegetation is affected by slope exposure and soil texture. The heavy, frequently waterlogged soil of the valley bottoms supports meadows of mixed grasses and herbs. North-facing slopes permit *Picea engelmannii* and *Abies lasiocarpa* to extend to lower elevations than on the level plateau surface. The south-facing valley slopes are frequently choked with thickets of deciduous shrubs under a canopy of *Populus tremuloides.* In protected situations some forest species extend over the rim onto steep canyon slopes. *Pinus ponderosa and Pseudotsuga menziesii* are commonly found in such slopes with an understory of deciduous shrubs including *Quercus gambelii, Robinia neomexicana* and *Amelanchier utahensis.*

Forested areas on plateaus other than the Kaibab Plateau are all below 7,600 feet elevation, and consequently do not possess the variety of tree species found on the Kaibab Plateau. The lower elevation plateaus (Powell, Uinkaret and the South Rim) are characterized by *Pinus ponderosa* forests with deciduous species, particularly *Quercus gambelii*, and *Pinus ponderosa* associated with *Pinus edulis, Artemisia tridentata* and other woodland and cold-desert species.

Descriptions of the seventeen forest associations used as mapping units in Grand Canyon follow here.

121.3111

Name: *Picea engelmannii - Abies lasiocarpa*
(Engelmann Spruce - Subalpine Fir)

Distribution: Elevational range is 7,500 to 8,900 feet (2,290 to 2,710 meters). This type is usually restricted to moderately steep slopes on north, northwest and northeast aspects. Soils are relatively deep with loamy texture, derived from the Kaibab Limestone. Fallen dead timber and deep litter are common on the forest floor. This type occurs throughout the North Rim near type 122.3221 which is restricted to southerly slope aspects at similar elevations.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (23)
Picea engelmannii	Engelmann spruce	1 - 5	3.5	1.0
Abies lasiocarpa	alpine fir	2 - 4	3.4	0.9
Populus tremuloides	aspen	2 - 4	3.0	0.9
Associated Species				
Juniperus communis	dwarf juniper	1 - 3	2.4	0.6
Pinus ponderosa	ponderosa pine	1 - 3	2.1	0.6
Pseudotsuga menziesii	Douglas fir	1 - 4	2.2	0.3
Abies concolor	white fir	1 - 4	2.3	0.3
Carex spp.	sedge	1 - 3	2.0	0.5
Robinia neomexicana	New Mexican locust	3	3.0	0.1

Occasional Species: *Pteridium aquilinum, Berberis repens, Lupinis* spp., *Lotus utahensis, Mimulus* sp., *Fragaria* sp.

Physiognomy: Evergreen needle-leaved forest in evenly spaced stands. Deciduous broad-leaved trees grow in irregularly distributed patches throughout the type. Low growing evergreen scale-leaved dwarf shrubs may occupy the forest floor. Ground cover is sparse, composed of grasses, sedges and herbs. The trees are 15 to 60 feet (5 to 18 meters) tall, and the shrubs are less than 3 feet (0.9 meters) tall. Estimated total cover ranges from 50 to 75 percent, or sometimes greater.

121.3171

Name: *Picea engelmannii - Abies concolor - Pinus ponderosa*
(Engelmann Spruce - White Fir - Ponderosa Pine)

Distribution: Elevational range is 8,300 to 9,150 feet (2,530 to 2,790 meters). This type is found on nearly level to moderately steep slopes of all aspects. Soils are moderately deep with loamy texture derived from the Kaibab Limestone. Fallen dead timber and deep litter is extensive on the forest floor. This type occurs in the northeastern region of the North Rim. The local name of this area is the Iron Triangle, referring to the inaccessibility of the area caused by fallen timber on the forest floor.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (23)
Picea engelmannii	Engelmann spruce	2 - 4	3.3	0.8
Abies concolor	white fir	2 - 4	3.2	0.8
Pinus ponderosa	ponderosa pine	1 - 4	2.8	0.8
Populus tremuloides	aspen	2 - 4	3.4	1.0
Pseudotsuga menziesii	Douglas fir	1 - 3	2.7	0.6
Abies lasiocarpa	alpine fir	2 - 4	3.3	0.5
Associated Species				
Juniperus communis	dwarf juniper	1 - 2	1.2	0.5
Robinia neomexicana	New Mexican locust	2 - 3	2.8	0.3

Occasional Species: *Berberis repens, Ribes* sp., *Poa pratensis, Lotus utahensis, Fragaria* sp., *Pteridium aquilinum.*

Physiognomy: Evergreen needle-leaved forest of evenly spaced stands. Deciduous broad-leaved trees growing in patches are irregularly distributed throughout the type. The understory may be composed of deciduous broad-leaved shrubs or evergreen scale leaved dwarf-shrubs. Ground cover is sparse and is composed of grasses, sedges and herbs. Trees are 15 to 60 feet tall (5 to 18 meters). Shrubs are 10 feet (3 meters) tall or less. Estimated total cover ranges from 50 to 75 percent or greater.

121.3172

Name: *Populus tremuloides - Pinus ponderosa - Picea engelmannii* (Aspen - Ponderosa Pine - Engelmann Spruce)

Distribution: Elevational range is 8,500 to 9,100 feet (2,590 to 2,770 meters). The type occurs on level to rolling terrain of all aspects and on ridges and swales. Soils are moderately deep with loamy texture derived from the Kaibab Limestone. The soil may be covered with accumulations of organic matter from deciduous shrubs and herbs. This type is restricted to the northeast corner of the North Rim.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (2)
Populus tremuloides	aspen	4 - 5	4.5	1.0
Pinus ponderosa	ponderosa pine	3	3.0	1.0
Picea engelmannii	Engelmann spruce	3	3.0	0.5
Associated Species				
Pseudotsuga menziesii	Douglas fir	3	3.0	0.5
Abies concolor	white fir	3	3.0	0.5
Juniperus communis	dwarf juniper	2	2.0	0.5

Occasional Species: *Fragaria* sp., *Cirsium* sp., *Geranium caespitosum*, *Pteridium aquilinum*, *Carex* sp., *Lotus utahensis*, *Berberis repens*.

Physiognomy: Deciduous broad-leaved forest in evenly spaced or patchy stands. Mixed evergreen needle-leaved trees are distributed throughout the forest in the canopy, or in the understory, where evergreen scale-leaved dwarf-shrubs also occur. Herbaceous ground cover is common. Trees are 15 to 30 feet (5 to 9 meters) tall, although evergreen needle-leaved trees may be shorter. Estimated total cover ranges from 35 to 75 percent. Some occurrences of the type represent early seral stages following recent burns, while others appear to represent more mature forest stands.

122.3121

Name: *Pseudotsuga menziesii - Abies concolor - Robinia neomexicana* (Douglas Fir - White Fir - New Mexican Locust)

Distribution: Elevational range is 5,600 to 8,800 feet (1,710 to 2,680 meters). The type is found on protected steep talus slopes near cliffs usually on northeast or north aspects. Soils are rocky, derived from the Kaibab Limestone, Toroweap Formation, Coconino Sandstone, Hermit Shale, Supai Group and Redwall Limestone. This type occurs on the highest elevations of the inner canyon, on the east side of the Walhalla Plateau from Point Imperial to Cape Royal.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (7)
Pseudotsuga menziesii	Douglas fir	3 - 4	3.4	1.0
Abies concolor	white fir	1 - 5	3.4	1.0
Robinia neomexicana	New Mexican locust	2 - 4	3.2	0.7
Quercus gambelii	Gambel oak	2 - 4	3.1	0.6
Ptelea trifoliata	hop-tree	2 - 3	2.7	0.6
Fendlera rupicola	fendlerbush	2	2.0	0.6
Associated Species				
Pinus edulis	pinyon pine	2 - 4	3.5	0.4
Ribes viscosissimum	gooseberry	2	2.0	0.4
Berberis repens	creeping mahonia	2 - 3	2.3	0.4
Symphoricarpos sp.	snowberry	2 - 3	2.3	0.4
Ostrya knowltoni	hop-hornbeam	3 - 5	4.0	0.3
Cercocarpus intricatus	little-leaf mountain-mahogany	2 - 3	2.5	0.3
Pinus ponderosa	ponderosa pine	2 - 3	2.5	0.3
Rosa arizonica	rose	1 - 2	1.5	0.3
Phlox austromontana	———	1 - 2	1.5	0.3

Occasional Species: *Cercocarpus montanus, Agave utahensis, Gutierrezia sarothrae, Cercis occidentalis, Ribes montigenum, Sambucus neomexicana, Amelanchier utahensis, Ephedra viridis, Galium* sp., *Holodiscus dumosus, Cercocarpus ledifolius, Juniperus osteosperma, Artemisia ludoviciana, Chrysothamnus* spp.

Physiognomy: Evergreen needle-leaved forest in even to irregularly spaced stands. Mixed deciduous shrubs occur in patches throughout the understory. Trees are up to 60 feet (18 meters) tall and shrubs vary from 2 to 12 feet (0.6 to 3.6 meters) tall. Estimated total cover is 50 to 60 percent, but may be less in the lower more xeric extensions of the habitat.

122.3211

Name: *Pinus ponderosa - Populus tremuloides - Picea engelmannii* (Ponderosa Pine - Aspen - Engelmann Spruce)

Disribution: Elevational range is 7,800 to 8,200 feet (2,380 to 2,500 meters). The type is found on broad shallow drainage bottoms and lower slopes of all aspects. Soils are deep and well developed with loamy texture derived from the Kaibab Limestone. The type is mapped on the Walhalla Plateau, but may occur elsewhere on the North Rim in stands too small to be mapped.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (3)
Pinus ponderosa	ponderosa pine	2 - 4	3.0	1.0
Populus tremuloides	aspen	3	3.0	1.0
Picea engelmannii	Engelmann spruce	3 - 4	3.5	0.6

Associated and Occasional Species: Various herbs.

Physiognomy: Deciduous broad-leaved forest in irregular patches. Evergreen needle-leaved trees are distributed throughout. Herbaceous ground cover is abundant. Trees are usually over 30 feet (9 meters) tall. Estimated total cover is greater than 50 percent. *Populus tremuloides* grows on drainage bottoms and low slopes while *Pinus ponderosa* is usually restricted to slopes grading into this type (Fig. 5).

Figure 5. *Pinus ponderosa* with forbs (122.3212) located south of Kanabownits Spring on the Kaibab Plateau. This stand illustrates the openness and low floristic diversity of the type.

122.3212

Name: *Pinus ponderosa* (Ponderosa Pine)

Distribution: Elevational range is 7,200 to 8,200 feet (2,190 to 2,500 meters). The type is found on nearly level to gently sloping terrain on all aspects. Soils are shallow and slightly cobbly with loamy texture, derived from the Kaibab Limestone. Leaf litter is common throughout the type. The type is located on the North Rim where it is found on the lower elevational plateau areas of the Walhalla Plateau, Point Sublime and the Rainbow Plateau. It occurs in extensive uniform stands, sometimes interrupted by more diverse vegetation types in drainages, or by 122.3231 which has a patchy distribution.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (8)
Pinus ponderosa	ponderosa pine	5	5.0	1.0
Associated Species				
Abies concolor	white fir	1 - 2	1.7	0.5
Poa pratensis	bluegrass	3	3.0	0.5
Populus tremuloides	aspen	2 - 3	2.3	0.4
Eriogonum cf. racemosum	buckwheat	1 - 2	1.6	0.4
Lupinus hillii	lupine	2 - 3	2.3	0.4

Occasional Species: *Ceanothus fendleri, Cowania mexicana, Quercus gambelii, Pseudotsuga menziesii, Robinia neomexicana, Rosa arizonica, Achillea lanulosa, Carex* sp.

Physiognomy: Evergreen needle-leaved forest of evenly spaced open stands. Deciduous or evergreen sclerophyllous shrubs are uncommon in the understory. Herbaceous ground cover is abundant. Trees are 30 to 50 feet (9 to 15 meters) tall. Estimated total cover ranges from 30 to 70 percent.

122.3221

Name: *Pinus ponderosa - Populus tremuloides - Abies concolor - Pseudotsuga menziesii* (Ponderosa Pine - Aspen - White Fir - Douglas Fir)

Distribution: Elevational range is 8,100 to 8,900 feet (2,470 to 2,710 meters). This type is most commonly found on moderately steep slopes of south aspects and on level ridgetops. Soils are moderately deep with loamy texture derived from the Kaibab Limestone. Leaf litter and dead wood are common on the forest floor. This type occurs on the North Rim where it forms a broad transition between 122.3171 of lower elevations and 121.3171 of higher elevations.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (23)
Pinus ponderosa	ponderosa pine	2 - 5	3.4	1.0
Populus tremuloides	aspen	1 - 4	2.9	1.0
Abies concolor	white fir	1 - 4	2.3	0.8
Pseudotsuga menziesii	Douglas fir	1 - 4	2.2	0.5
Picea engelmannii	Engelmann spruce	2 - 4	3.4	0.6
Associated Species				
Juniperus communis	dwarf juniper	1 - 3	2.3	0.4
Abies lasiocarpa	alpine fir	1 - 4	2.3	0.1

Occasional Species: *Arctostaphylos pungens, Ceanothus fendleri, Rosa arizonica, Robinia neomexicana, Quercus gambelii, Poa pratensis, Berberis repens, Pteridium aquilinum, Lotus utahensis, Achillea lanulosa*

Physiognomy: Evergreen needle-leaved forest in evenly spaced stands. Deciduous broad-leaved trees are distributed irregularly throughout. The understory may contain mixed deciduous broad-leaved shrubs and sclerophyllous shrubs, and scale-leaved dwarf-shrubs. Ground cover is composed of herbs and grasses. Trees are 15 to 60 feet (5 to 18 meters) tall and shrubs are less than 10 feet (3 meters) tall, of variable height. Estimated total cover ranges from 50 to 75 percent. This type is similar to 122.327 (*Pinus ponderosa - Abies concolor* Association) but differs in the proportions of *Pseudotsuga menziessii* and *Pinus ponderosa*. *P. menziesii* is more common in this type, especially at higher elevations. The two converge along a wide gradient at the lower elevational range of this type.

122.3222

Name: *Populus tremuloides - Pinus ponderosa - Picea engelmannii* (Aspen - Ponderosa Pine - Engelmann Spruce)

Distribution: Elevational range is 8,000 to 8,800 feet (2,440 to 2,680 meters). The type is located on low to moderately steep slopes on all aspects, but usually not north-facing. Soils are moderately deep with loamy texture derived from Kaibab Limestone.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (2)
Populus tremuloides	aspen	4	4.0	1.0
Pinus ponderosa	ponderosa	2 - 3	2.5	1.0
Associated Species				
Picea engelmannii	Engelmann spruce	4	4.0	0.5
Abies concolor	white fir	3	3.0	0.5
Juniperus communis	dwarf juniper	3	3.0	0.5
Pseudotsuga menziesii	Douglas fir	2	2.0	0.5
Abies lasiocarpa	alpine fir	2	2.0	0.5

Occasional Species: *Carex* sp., *Lotus utahensis, Berberis repens.*

Physiognomy: The type differs from 122.3221 in having more deciduous broad-leaved trees (Fig. 6).

Figure 6. *Populus tremuloides - Pinus ponderosa* (122.3222) located on the west side of The Basin, Kaibab Plateau. Sapling *Abies concolor* and *Pinus ponderosa* are growing up under the canopy of *Populus tremuloides* which they will eventually replace as dominants in the stand.

122.3231

Name: *Pinus ponderosa - Robinia neomexicana - Quercus gambelii* (Ponderosa Pine - New Mexican Locust - Gambel's Oak)

Distribution: Elevational range is 6,900 to 8,100 feet (2,100 to 2,470 meters). This type is usually restricted to moderately steep slopes of north aspect; found occasionally on more level areas. Soils are moderately deep with loamy texture, derived from the Kaibab Limestone. This type occurs at lower elevations on the North Rim at Swamp Point, Point Sublime, Rainbow Point, Tiyo Point, Widforss Point and on the Powell Plateau.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (12)
Pinus ponderosa	ponderosa pine	3 - 5	4.1	1.0
Robinia neomexicana	New Mexican locust	2 - 4	2.7	1.0
Quercus gambelii	gambel oak	2 - 4	3.1	0.7
Associated Species				
Populus tremuloides	aspen	2 - 4	2.6	0.4
Berberis repens	creeping mahonia	1 - 3	2.0	0.4
Abies concolor	white fir	1 - 2	1.6	0.2

Occasional Species: *Cercocarpus montanus, Symphoricarpos* sp., *Rosa arizonica, Eriogonum racemosum, Cowania mexicana, Geranium* sp., *Poa pratensis, Lupinus hillii.*

Physiognomy: Evergreen needle-leaved forest in open parkland-like stands. Deciduous shrubs are patchily distributed in clumps in the understory, often forming thickets. Herbaceous ground cover is variable from one locality to another. Trees are up to 60 feet (18 meters) tall and shrubs are usually less than 10 feet (3 meters) tall. Estimated total cover is 35 to 50 percent. *Populus tremuloides* occurs in drainages at higher elevations in the type.

122.3232

Name: *Pinus ponderosa - Pinus edulis - Cowania mexicana - Artemisia nova* (Ponderosa Pine - Pinyon Pine - Cliffrose - Black Sagebrush)

Distribution: Elevational range is 7,600 to 8,000 feet (2,320 to 2,440 meters). The type is usually found on level to undulating terrain on all aspects. Soils are shallow with a loamy texture and some cobbles and gravel derived from the Kaibab Limestone. This type usually occurs in a narrow band along exposed edges of the rim and on exposed prominences of the Walhalla Plateau.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (3)
Pinus ponderosa	ponderosa pine	2 - 3	2.3	1.0
Pinus edulis	pinyon pine	3	3.0	1.0
Cowania mexicana	cliffrose	3 - 4	3.6	1.0
Artemisia nova	black sagebrush	4	4.0	0.6
Associated Species				
Poa pratensis	bluegrass	3 - 4	3.5	0.6
Eriogonum spp.	buckwheat	3	3.0	0.6
Bouteloua gracilis	blue grama	3	3.0	0.6
Aster sp.	aster	2	2.0	0.6
Tetradymia axillaris	cotton-thorn	2	2.0	0.6

Occasional Species: *Abies concolor, Quercus gambelii, Symphoricarpus* sp., *Juniperus osteosperma, Fendlera rupicola, Ribes* sp., *Opuntia* sp., *Berberis repens, Linum lewesii, Oryzopsis hymenoides, Coryphantha* sp.

Physiognomy: Evergreen needle-leaved parkland and/or woodland in open, unevenly scattered stands. Sclerophyllous shrubs and broad-leaved deciduous shrubs occur in patches, often forming thickets. Microphyllous shrubs may be evenly distributed throughout the type, interspersed with herbaceous ground cover. Trees are 15 to 60 feet (5 to 18 meters) and shrubs are less than 2 to 8 feet (0.6 to 2.4 meters) tall. Estimated total cover is 30 to 60 percent.

122.3233

Name: *Pinus ponderosa - Pinus edulis - Quercus gambelii - Juniperus osteosperma* (Ponderosa pine - Pinyon Pine - Gambel Oak - Juniper)

Distribution: Elevational range is 6,000 to 7,500 feet (1,830 to 2,290 meters). This type is found on level to gently sloping terrain of all aspects. Soils are moderately shallow, sometimes with cobbles, with silty loam texture, derived from the Kaibab Limestone or volcanic outcrops. This type occurs on the South Rim and at Slide Mountain and the Pine Mountains west of Toroweap Valley. The type forms a transition from *Pinus edulis, Juniperus sp.* bordering lower elevations to pure *Pinus ponderosa* dominated forests at higher elevations.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (24)
Pinus ponderosa	ponderosa pine	2 - 5	4.1	1.0
Pinus edulis	pinyon pine	2 - 5	3.3	0.9
Quercus gambelii	Gambel oak	2 - 4	3.0	0.9
Juniperus osteosperma	Utah juniper	1 - 4	2.8	0.8
Artemisia tridentata	big sagebrush	2 - 4	2.7	0.8
Poa pratensis	bluegrass	2 - 3	2.9	0.8
Associated Species				
Lupinus hillii	lupine	1 - 3	2.0	0.4
Yucca baccata	banana yucca	1 - 2	1.7	0.3
Cowania mexicana	cliff-rose	1 - 3	2.0	0.2
Berberis repens	creeping mahonia	2	2.0	0.2
Symphoricarpos sp.	snowberry	1 - 3	2.0	0.2

Occasional Species: *Amelanchier utahensis, Ribes* sp., *Eriogonum* sp., *Robinia neomexicana, Chrysothamnus nauseosus, Bromus tectorum, Capsella bursa-pastoris, Bouteloua gracilis, Penstemon barbatus, Coryphantha vivipara, Opuntia phaeacantha, Gutierrezia sarothrae, Sambucus mexicana, Chamaebatiaria millefolium, Sheperdia rotundifolia, Rhus trilobata, Townsendia* sp., *Fallugia paradoxa, Agropyron smithii, Eriogonum wrightii, Chrysopsis villosa, Sitanion hystrix, Lotus utahensis, Phlox austromontana, Bouteloua curtipendula.*

Physiognomy: Evergreen needle-leaved and scale-leaved forest and/or woodland in uneven stands. Microphyllous dwarf-shrubs are prominent in the understory. Deciduous broad-leaved shrubs occur in mesic pockets. Trees vary from 20 to 60 feet (6 to 18 meters) tall. Shrubs are less than 6 feet (1.8 meters) tall. Estimated total cover is 20 to 50 percent.

122.3234

Name: *Pinus ponderosa - Quercus gambelii - Artemisia tridentata* (Ponderosa Pine - Gambel Oak - Big Sagebrush)

Distribution: Elevational range is 6,500 to 7,400 feet (1,980 to 2,250 meters). This type is restricted to moderate slopes of north or northwest aspects and in drainages. Soils are often gravelly, with sandy to silty loam texture, derived from the Kaibab Limestone. The type is localized, found in South Rim drainages such as Bright Angel Wash, Long Jim Canyon and near Rowe's Well. The type intergrades with 122.3233 on ridgetops.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (4)
Pinus ponderosa	ponderosa pine	4 - 5	4.7	1.0
Quercus gambelii	Gambel oak	2 - 4	3.0	1.0
Artemisia tridentata	big sagebrush	1 - 4	2.5	1.0
Poa pratensis	bluegrass	2 - 4	2.5	1.0
Associated Species				
Penstemon sp.	beard-tongue	1 - 2	1.3	0.7
Ribes sp.	gooseberry	1	1.0	0.7
Lupinus hillii	lupine	3	3.0	0.5

Occasional Species: *Juniperus osteosperma, Chrysothamnus viscidiflorus, Rosa arizonica, Berberis repens, Opuntia* sp., *Cowania mexicana, Bouteloua curtipendula, Phlox austromontana.*

Physiognomy: Evergreen needle-leaved forest in uniform stands. Deciduous broad-leaved shrubs form thickets in the understory. Microphyllous dwarf-shrubs and herbaceous ground cover is common. Trees are 60 feet (18 meters) tall, and shrubs are less than 12 feet (4 meters) tall. Estimated total cover is 30 to 40 percent.

122.3261

Name: *Pinus ponderosa - Populus tremuloides - Picea engelmannii* (Ponderosa Pine - Aspen - Engelmann Spruce)

Distribution: Elevational range is 8,100 to 8,400 feet (2,470 to 2,560 meters). This type is found on nearly level to moderately sloping terrain of all aspects. Soils are moderately shallow and gravelly, with sandy loam texture and are derived from the Coconino Sandstone and Toroweap Formation. The type is restricted on the North Rim to the Basin where it occurs as forested pockets surrounded by meadow and in a wide strip surrounding the meadow. This type blends into 122.3221 on Kaibab Limestone.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (11)
Pinus ponderosa	ponderosa pine	1 - 4	3.3	1.0
Populus tremuloides	aspen	2 - 4	3.2	1.0
Picea engelmannii	Engelmann spruce	3 - 4	3.9	1.0
Associated Species				
Juniperus communis	dwarf juniper	2 - 3	2.5	0.5
Abies concolor	white fir	2	2.0	0.3
Lupinus cf. hillii	lupine	1	1.0	0.1

Occasional Species: *Castilleja* sp., *Potentilla* sp., *Poa pratensis*, *Lotus utahensis*, *Fragaria* sp.

Physiognomy: Evergreen needle-leaved forest in even stands. Deciduous broad-leaved trees are irregularly distributed throughout the type forming patches. Evergreen scale-leaved dwarf-shrubs are common. Herbaceous ground cover is variable. Trees are up to 60 feet (18 meters) in height. Estimated total cover is 25 to 70 percent (Fig. 7).

Figure 7. *Pinus ponderosa* - *Populus tremuloides* - *Picea engelmannii* (122.3261) in The Basin near Horsethief Spring. This type occurs on rolling terrain with soil derived from Coconino Sandstone, unlike most other forest types which occur on limestone. *Pinus ponderosa* with rounded crowns and *Picea engelmannii* with narrow pointed crowns are evenly mixed on the hillside

122.3271

Name: *Pinus ponderosa - Abies concolor - Populus tremuloides* (Ponderosa Pine - White Fir - Aspen)

Distribution: Elevational range is 7,800 to 8,900 feet (2,380 to 2,710 meters). This type is found on level to moderately sloping terrain with southerly and occasionally northerly aspects. Soils are moderately deep of silty loam texture derived from the Kaibab Limestone. Leaf litter and fallen dead timber is common. The type is widely distributed on the North Rim.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (84)
Pinus ponderosa	ponderosa pine	1 - 5	3.6	1.0
Abies concolor	white fir	1 - 5	3.0	0.9
Populus tremuloides	aspen	1 - 4	3.2	0.9
Associated Species				
Picea engelmannii	Engelmann spruce	2 - 4	3.5	0.4
Pseudotsuga menziesii	Douglas fir	1 - 4	2.2	0.3
Robinia neomexicana	New Mexican locust	2 - 5	2.7	0.3
Juniperus communis	dwarf juniper	1 - 3	1.9	0.2

Occasional Species: *Rosa arizonica, Berberis repens, Quercus gambelii, Arctostaphylos pungens, Symphoricarpos* sp., *Ceanothus fendleri, Abies lasiocarpa, Ptelea trifoliata, Rubus parviflorus, Rhus trilobata, Sambucus neomexicana, Artemisia dracunculoides, Chamaebatiaria millefolium, Thalictrum* sp., *Ribes viscosissimum.*

Physiognomy: Evergreen needle-leaved forest in even stands. Deciduous broad-leaved trees are distributed irregularly throughout, often forming patches. Broad-leaved deciduous shrubs form thickets when present. Evergreen scale-leaved dwarf-shrubs and herbaceous ground cover is sometimes present. Trees are up to 60 feet (18 meters) tall. Shrubs are 6 feet (1.8 meters) tall or less. Estimated total cover is 40 percent or greater. *Populus tremuloides* and *Abies concolor* are more prominent at the higher elevations of the type. *Robinia neomexicana* is more prominent at lower elevations. *Picea engelmannii* occurs primarily on low slopes (Fig. 8).

Figure 8. *Pinus ponderosa* - *Abies concolor* - *Populus tremuloides* type (122.3271) located on the Walhalla Plateau. *Abies concolor* in the background is invading open stands of *Pinus ponderosa* shown in the foreground, possibly as a result of fire suppression. Dead wood accumulation is also an indication of the absence of fires.

122.3272

Name: *Pinus ponderosa - Abies concolor - Populus tremuloides - Robinia neomexicana* (Ponderosa Pine - White Fir - Aspen - New Mexican Locust)

Distribution: Elevational range is 8,000 to 8,600 feet (2,440 to 2,620 meters). The type is found on moderate to steep slopes of nearly all aspects. Soils are moderately deep with loamy texture derived from the Kaibab Limestone. This type is situated on the landbridge between the Walhalla Plateau and the North Rim.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (8)
Pinus ponderosa	ponderosa pine	2 - 3	2.3	0.9
Abies concolor	white fir	3 - 4	3.2	1.0
Populus tremuloides	aspen	2 - 4	3.2	1.0
Robinia neomexicana	New Mexican locust	1 - 5	3.0	0.7
Pseudotsuga menziesii	Douglas fir	1 - 3	2.2	0.9
Associated Species				
Quercus gambelii	Gambel oak	2 - 4	2.5	0.3
Arctostaphylos pungens	manzanita	2 - 4	3.0	0.2
Picea engelmannii	Engelmann spruce	2 - 4	3.0	0.2

Occasional Species: *Abies lasiocarpa, Berberis repens, Rosa arizonica, Pteridium aquilinum, Carex* sp.

Physiognomy: Evergreen needle-leaved forest in even stands. Broad-leaved deciduous trees and mixed broad-leaved and sclerophyllous shrubs form irregular stands and dense thickets in the understory. Trees are 60 feet (18 meters) tall or less and shrubs are 6 feet (1.8 meters) tall or less. Estimated total cover is 50 percent or greater.

122.3273

Name: *Abies concolor - Pinus ponderosa - Populus tremuloides* (White Fir - Ponderosa Pine - Aspen)

Distribution: Elevational range is 8,100 to 8,500 feet (2,470 to 2,590 meters). The type is found in drainages and on lower to mid slopes, primarily on east and west aspects. Soils are moderately deep, of loamy texture derived from the Kaibab Limestone. Leaf litter and fallen dead timber are not heavy. This type forms pockets within the widely distributed type 122.3271 on the North Rim.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency (4)**
Abies concolor	white fir	1 - 3	2.6	1.0
Pinus ponderosa	ponderosa pine	3 - 5	4.0	0.8
Populus tremuloides	aspen	3 - 4	3.2	0.8
Associated Species				
Poa pratensis	bluegrass	3	3.0	0.6
Robinia neomexicana	New Mexican locust	3 - 4	3.5	0.4
Berberis repens	creeping mahonia	2	2.0	0.4
Symphoricarpos sp.	snowberry	3	3.0	0.2
Quercus gambelii	Gambel oak	3	3.0	0.2

Physiognomy: Evergreen needle-leaved forest in uneven stands. Broad-leaved deciduous trees common, often forming clusters. The evergreens are often young and in the understory of the deciduous trees. Ground cover is usually sparse. Trees are up to 50 feet (15 meters) tall. Estimated total cover is 50 to 75 percent.

122.3274

Name: *Pinus ponderosa - Quercus gambelii - Abies concolor - Robinia neomexicana* (Ponderosa Pine - Gambel's Oak - White Fir - New Mexican Locust

Distribution: Elevational range is 5,200 to 8,400 feet (1,580 to 2,560 meters). The type is found on extremely steep protected slopes of all aspects. Soils are composed of talus slopes stabilized by vegetation, derived from the Kaibab Limestone, Toroweap Formation, Coconino Sandstone and sometimes the Hermit Shale. Rock outcrops and loose talus are common. This type is distributed irregularly, depending on aspect, from The Dragon to Point Imperial on the north side of the canyon. A small stand is present but not mapped on the South Rim near Hance Canyon, at the Sinking Ship.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (19)
Pinus ponderosa	ponderosa pine	1 - 4	2.4	0.8
Quercus gambelii	Gambel oak	1 - 5	3.0	0.8
Abies concolor	white fir	1 - 5	3.5	0.8
Robinia neomexicana	New Mexican locust	2 - 4	3.2	0.7
Amelanchier utahensis	serviceberry	2 - 4	3.0	0.6
Symphoricarpos sp.	snowberry	2 - 3	2.2	0.6
Associated Species				
Pseudotsuga menziesii	Douglas fir	2 - 5	3.2	0.4
Pinus edulis	pinyon pine	3 - 4	3.5	0.3
Holodiscus dumosus	rock spiraea	2 - 3	2.4	0.3
Acer grandidentatum	big-tooth maple	1 - 3	2.3	0.3
Juniperus osteosperma	Utah juniper	1 - 4	2.6	0.3
Berberis repens	creeping mahonia	1 - 3	2.0	0.3
Ceanothus fendleri	buckbrush	2	2.0	0.2
Rosa arizonica	rose	1 - 3	2.0	0.2

Occasional Species: *Ribes* sp., *Populus tremuloides, Thalictrum* sp., *Penstemon* spp., *Rubus parviflorus, Oryzopsis hymenoides, Sambucus neomexicana, Garrya flavescens, Poa pratensis, Yucca baccata, Fendlerella utahensis, Cowania mexicana, Cercocarpus ledifolius, Cercocarpus montanus, Arctostaphylos pungens, Ostrya knowltoni.*

Physiognomy: Evergreen needle-leaved forest and woodland in open stands. Broad-leaved deciduous trees and mixed broad-leaved and sclerophyllous shrubs may form dense understories. Succulents and herbaceous ground cover are also present. Trees are usually less than 60 feet (18 meters) tall. Estimated total cover is 70 to 100 percent. This type is similar to 122.4148. This inner canyon type differs greatly from forest types on the plateaus because *Populus tremuloides* is nearly always absent.

122.7111

Name: *Populus tremuloides*
(Aspen)

Distribution: Elevational range is 7,600 to 8,800 feet (2,320 to 2,680 meters). This type is found on slopes of all grades and aspects. Soils are usually relatively deep with loamy texture, derived from the Kaibab Limestone. This type is distributed in patches throughout the evergreen needle-leaved forests on the North Rim. Two stands are large enough to be mapped.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (2)
Populus tremuloides	aspen	4	4.0	1.0
Associated Species				
Pinus ponderosa	ponderosa pine	2	2.0	1.0
Abies concolor	white fir	2	2.0	0.5
Picea engelmannii	Engelmann spruce	2	2.0	0.5
Juniperus communis	dwarf juniper	2	2.0	0.5
Robinia neomexicana	New Mexican locust	3	3.0	0.5
Symphoricarpos sp.	snowberry	2	2.0	0.5
Lupinus hillii	lupine	1	1.0	0.5
Poa pratensis	bluegrass	1	1.0	0.5

Physiognomy: Deciduous broad-leaved forest in evenly spaced stands or clumps. Coniferous trees are distributed irregularly throughout the upper canopy. Deciduous broad-leaved saplings often occur in the understory. Deciduous broad-leaved shrubs may occur in the understory. Ground cover is variable, with evergreen dwarf-shrubs, herbaceous cover or almost no ground cover depending on the site. The trees are 15 to 60 feet (5 to 18 meters) tall and the shrubs are 8 feet (2.4 meters) tall or less. Estimated total cover ranges from 60 to 70 percent.

Woodlands

Evergreen woodlands are distributed throughout the park between approximately 4,000 and 7,500 feet elevation. In all areas, *Pinus edulis* and *Juniperus osteosperma* are the dominant tree species. The associated shrub understory has a high species diversity. Woodland associations occupy three main physiographic locations within the park: plateau tops, steep canyon slopes, and inner canyon terraces. The physiographic location influences the floristic composition and diversity of the understory to a large extent.

The least diverse woodland associations are found on top of the plateaus. *Artemisia tridentata* and a few other Great Basin desertscrub species are found as frequent associates, but the number of shrub species is low and in some areas completely absent.

Woodland vegetation found on steep canyon walls is highly variable in the park. Immediately below the rim on slopes with northerly exposure the associated shrubs are mostly deciduous montane species such as *Amelanchier utahensis*, *Symphoricarpos* sp., *Robinia neomexicana* and *Quercus gambelii*. Farther down the canyon slopes deciduous species are replaced by evergreen sclerophyll chaparral shrubs, especially *Quercus turbinella*, *Garrya flavescens*, *Arctostaphylos pungens* and others. Patches of chaparral without trees are common in woodland areas, but are generally too small to map individually. Still farther down the canyon slopes chaparral species are replaced by a variety of desertscrub species, most of which are evergreen.

Bedrock terraces of varying size occur throughout the canyon, but the large terraces of the Esplanade support woodland only between approximately 4,500 and 5,500 feet. The floristic composition of woodland understory on bedrock terraces is a complex mixture of desertscrub species and higher elevation chaparral species. This floristic mixing results from the water-catchment characteristics of bedrock surfaces which provide sufficient moisture availability in soil pockets to support mesic species at elevations which ordinarily support desertscrub species.

Descriptions of the twelve woodland associations, including interspersed chaparral, used as mapping units at Grand Canyon follow here.

122.4141

Name: *Pinus edulis - Juniperus osteosperma - Quercus turbinella - Cercocarpus intricatus* (Pinyon pine - Juniper - Scrub Oak - Little-Leaf Mountain-Mahogany)

Distribution: Elevational range is 4,000 to 6,500 feet (1,220 to 1,980 meters). The type is found on slick-rock terraces. Soils are restricted to crevices and sandy soil pockets within extensive bedrock exposures of the Supai Group. The type extends from Toroweap Point east to Walhalla Plateau north of the river and from Fossil Bay east to Darwin Plateau south of the river on the Esplanade.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (58)
Pinus edulis	pinyon pine	2 - 5	3.7	1.0
Juniperus osteosperma	Utah juniper	1 - 4	3.0	0.8
Quercus turbinella/ undulata	scrub oak	1 - 4	3.0	0.9
Cercocarpus intricatus	little-leaf mountain-mahogany	2 - 5	3.5	0.7
Ephedra viridis	Mormon tea	1 - 3	2.4	0.9
Glossopetalon nevadense	grease-bush	2 - 4	3.3	0.7
Gutierrezia sarothrae	snakeweed	1 - 3	2.5	0.8
Agave utahensis	Utah agave	1 - 4	2.6	0.8
Yucca baccata	banana yucca	1 - 4	2.4	0.6
Ceanothus greggii	deerbrush	2 - 4	2.7	0.5
Associated Species				
Artemisia tridentata/ nova	sagebrush	1 - 3	2.3	0.5
Cercocarpus montanus	mountain-mahogany	1 - 4	2.4	0.4
Opuntia phaeacantha	prickly-pear cactus	1 - 4	2.2	0.4
Thamnosma montana	turpentine broom	1 - 2	1.6	0.4
Nolina microcarpa	bear grass	1 - 4	2.5	0.3
Opuntia erinacea	grizzly-bear cactus	2 - 3	2.5	0.3
Yucca angustissima	datil	1 - 3	2.2	0.3
Berberis fremontii	barberry	1 - 3	2.1	0.3
Poa pratensis	bluegrass	2 - 4	2.7	0.2
Chrysothamnus viscidiflorus	rabbitbrush	2 - 3	2.6	0.2
Cowania mexicana	cliffrose	1 - 4	1.8	0.2
Phlox austromontanus	———	1 - 2	1.4	0.2
Amelanchier utahensis	service berry	1 - 3	2.1	0.2
Bernardia incana	———	1 - 3	2.1	0.2
Psilostrophe sparsiflora	paper-flower	1 - 3	2.0	0.2
Arctostaphylos pungens	manzanita	1 - 3	2.0	0.2
Eriogonum wrightii	buckwheat	1 - 3	1.7	0.2
Echinocereus triglochidiatus	hedgehog cactus	1 - 2	1.2	0.2

Occasional Species: *Chrysothamnus nauseosus, Fraxinus anomala, Ptelea trifoliata, Fendlera rupicola, Lesquerella arizonica, Coleogyne ramosissima, Cryptantha capitata, Penstemon* spp., *Oryzopsis hymenoides, Lycium pallidum, Aster abatus.*

Physiognomy: Evergreen needle-leaved and scale-leaved woodland in open stands. The understory is diverse, composed of sclerophyllous evergreen shrubs and scattered succulents. Perennial grasses are not prominent. The trees are generally 10 to 15 feet (3 to 5 meters) tall and the shrubs are 2 to 5 feet (less than 1 to 2 meters) tall. Estimated total cover is low, usually 10 to 30 percent, because much ground surface is bare bedrock. The large expanses of bedrock serve as water catchments and a relatively mesic flora indicates that available moisture in rock crevices and soil pockets appears to be much higher than in other exposed sites at the same elevation.

122.4142

Name: *Juniperus osteosperma - Pinus edulis - Ephedra viridis - Quercus turbinella* (Juniper - Pinyon Pine - Mormon Tea - Scrub Oak)

Distribution: Elevational range is 3,800 to 7,600 feet (1,160 to 2,320 meters). This type is found on steep canyon walls and talus slopes of all aspects. Soils are typically coarse with many cobbles, derived from sandstone or limestone. The type occurs throughout the canyon north of the river from the Shivwits Plateau east to Nankoweap Valley.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (70)
Juniperus osteosperma	Utah juniper	1 - 5	3.3	1.0
Pinus edulis	pinyon pine	1 - 5	3.4	0.9
Ephedra viridis	Mormon tea	1 - 4	2.6	0.9
Quercus turbinella/ undulata	scrub oak	1 - 5	3.0	0.7
Gutierrezia sarothrae	snake weed	1 - 5	2.8	0.8
Yucca baccata	banana yucca	1 - 3	2.5	0.7
Agave utahensis	Utah agave	1 - 4	2.0	0.6
Associated Species				
Artemisia tridentata/ nova	sagebrush	1 - 5	2.7	0.4
Rhus trilobata	skunkbush	1 - 4	2.3	0.4
Shepherdia rotundifolia	buffaloberry	1 - 4	2.5	0.3
Cercocarpus montanus	mountain-mahogany	1 - 5	3.2	0.3
Chrysothamnus nauseosus	rabbitbrush	1 - 4	2.5	0.3
Cowania mexicana	cliffrose	1 - 4	2.4	0.3
Amelanchier utahensis	serviceberry	1 - 4	2.4	0.3
Opuntia erinacea	grizzly-bear cactus	1 - 3	2.1	0.3
Glossopetalon nevadense	greasebush	2 - 4	2.9	0.2
Ptelea trifoliata	hop-tree	2 - 3	2.6	0.2
Opuntia phaeacantha	prickly-pear cactus	2 - 3	2.3	0.2
Thamnosma montana	turpentine broom	1 - 3	2.2	0.2
Artemisia ludoviciana	worm-wood	1 - 3	2.2	0.2
Poa pratensis	bluegrass	1 - 3	2.2	0.2
Arctostaphylos pungens	manzanita	1 - 3	1.8	0.2
Echinocereus triglochidiatus	hedgehog cactus	1 - 3	1.6	0.2

Occasional Species: *Fraxinus anomala, Fallugia paradoxa, Eriogonum corymbosum, Berberis fremontii, Fendlera rupicola, Ceanothus greggii, Eriogonum wrightii, Bernardia incana, Brickellia atractyloides, Acourtia wrightii, Penstemon barbatus, Amsonia* sp., *Cercocarpus ledifolius.*

Physiognomy: Evergreen needle-leaved and scale-leaved woodland in open stands. The understory is composed of sclerophyllous evergreen shrubs with scattered deciduous shrubs and succulents. The trees are 10 to 20 feet (3 to 6 meters) tall and the shrubs are 1 to 4 feet (0.3 to 1.2 meters) tall. Estimated total cover ranges from 15 to 40 percent. Because it encompasses a large variety of topographic situations, local variation within this type is great. The principal feature of variation is proportion of evergreen and deciduous shrubs, with more deciduous species at higher elevations and on protected slopes.

122.4143

Name: *Juniperus osteosperma - Pinus edulis - Artemisia tridentata* (Utah juniper - Pinyon Pine - Big Sagebrush)

Distribution: Elevational range is 4,000 to 7,300 feet (1,220 to 2,220 meters). The type is found on gentle to moderate slopes, mostly inside the canyon. Soils are shallow with loamy texture and gravel but few cobbles. This type is found in scattered locations from Toroweap to Nankoweap including Mt. Emma, Hancock Knolls, Hermit Basin and Nankoweap Valley. It is generally found in isolated patches and commonly intergrades with other woodland associations, particularly 122.4142.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (26)
Juniperus osteosperma	Utah juniper	2 - 4	3.6	1.0
Pinus edulis	pinyon pine	1 - 5	3.5	1.0
Artemisia tridentata	big sagebrush	2 - 5	3.5	1.0
Ephedra viridis	Mormon tea	1 - 3	2.3	0.8
Yucca baccata	banana yucca	1 - 3	2.6	0.5
Associated Species				
Gutierrezia sarothrae	snakeweed	1 - 3	2.2	0.4
Quercus turbinella/ undulata	scrub oak	1 - 3	1.8	0.4
Poa pratensis	bluegrass	2 - 3	2.9	0.3
Amelanchier utahensis	serviceberry	2 - 3	2.3	0.3
Cowania mexicana	cliffrose	1 - 3	2.1	0.3
Opuntia phaeacantha	prickly-pear cactus	1 - 3	2.1	0.3
Castilleja sp.	paint brush	1 - 2	1.6	0.3
Berberis fremontii	barberry	1 - 3	2.4	0.2
Fallugia paradoxa	Apache-plume	1 - 4	2.2	0.2
Agave utahensis	Utah agave	1 - 3	2.2	0.2
Opuntia erinacea	grizzly-bear cactus	1 - 3	2.0	0.2
Ribes sp.	gooseberry	2	2.0	0.2

Occasional Species: *Bouteloua gracilis, Eriogonum wrightii, Fendlerella utahensis, Sphaeralcea* sp., *Rhus trilobata, Echinocereus triglochidiatus, Chamaebatiaria millefolium, Oryzopsis hymenoides, Arctostaphylos pungens, Ptelea trifoliata, Prunus fasciculata, Garrya flavescens.*

Physiognomy: Evergreen needle-leaved and scale-leaved woodland in uniformly spaced stands. Evergreen shrubs and microphyllous dwarf-shrubs are common, with scattered mixed succulents. The trees are 10 to 20 feet (3 to 6 meters) and the shrubs are 1 to 4 feet (0.3 to 1.2 meters) tall. Estimated total cover ranges from 20 to 50 percent.

122.4144

Name: *Juniperus osteosperma - Artemisia tridentata - Pinus edulis* (Juniper - Big Sagebrush - Pinyon Pine)

Distribution: Elevational range is 4,000 to 7,400 feet (1,220 to 2,250 meters). The type is found on level or gently rolling slopes of all aspects on the plateau tops. Soils are relatively deep of sandy-loam texture derived from Kaibab Limestone. This type covers extensive portions of the Kanab Plateau, Powell Plateau and South Rim. This relatively low-diversity type frequently occurs as a mosaic with 122.4145 which occupies rocky limestone outcrops that are scattered across the plateaus.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (43)
Juniperus osteosperma	Utah juniper	2 - 5	3.6	1.0
Artemisia tridentata	big sagebrush	1 - 5	3.6	1.0
Pinus edulis	pinyon pine	1 - 5	3.3	1.0
Yucca baccata	banana yucca	1 - 4	2.2	0.7
Ephedra viridis	Mormon tea	1 - 3	2.4	0.6
Associated Species				
Gutierrezia sarothrae	snakeweed	1 - 3	2.3	0.4
Opuntia phaeacantha	prickly-pear cactus	1 - 3	1.3	0.4
Poa pratensis	bluegrass	2 - 4	2.9	0.3
Opuntia whipplei	whipple cholla	1 - 2	1.4	0.3
Bouteloua gracilis	blue grama	2 - 3	2.6	0.2
Opuntia erinacea	grizzly-bear cactus	1 - 2	1.9	0.2
Chrysothamnus viscidiflorus	rabbitbrush	1 - 3	1.9	0.2
Cowania mexicana	cliffrose	1 - 3	1.5	0.2

Occasional Species: *Atriplex canescens, Oryzopsis hymenoides, Berberis fremontii, Eurotia lanata, Sitanion hystrix, Agave utahensis, Echinocereus triglochidiatus, Coryphantha vivipara, Psilostrophe sparsiflora, Lycium pallidum, Glossopetalon nevadense, Eriogonum* sp., *Penstemon* sp.

Physiognomy: Evergreen needle-leaved and scale-leaved woodland of even distribution. The understory is composed of evergreen microphyllous shrubs, succulents and perennial bunch grasses. The trees are 14 to 30 feet (5 to 9 meters) tall and the shrubs are 1 to 3 feet (0.3 to 0.9 meters) tall. Estimated total cover ranges from 20 to 50 percent.

122.4145

Name: *Pinus edulis - Juniperus osteosperma - Artemisia tridentata - Cowania mexicana* (Pinyon Pine - Juniper - Big Sagebrush - Cliffrose)

Distribution: Elevational range is 5,400 to 8,000 feet (1,640 to 2,440 meters). The type is found on low to rolling limestone outcrops of all aspects. Soils are shallow and rocky. derived from the Kaibab Limestone This type is widespread on the Kanab Plateau, Powell Plateau and on the South Rim. It is very similar to 122.4144, which usually surrounds it, differing in greater prominence of *Cowania mexicana* and higher species richness.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (66)
Pinus edulis	pinyon pine	2 - 5	3.8	1.0
Juniperus osteosperma	Utah juniper	1 - 5	3.6	1.0
Artemisia tridentata	big sagebrush	1 5	3.5	0.9
Cowania mexicana	cliffrose	1 - 4	2.9	1.0
Gutierrezia sarothrae	snakeweed	1 - 3	2.3	0.6
Ephedra viridis	Mormon tea	1 - 3	2.1	0.6
Associated Species				
Yucca baccata	banana yucca	1 - 3	2.2	0.5
Opuntia phaeacantha	prickly-pear cactus	1 - 3	1.9	0.5
Poa pratensis	bluegrass	2 - 4	3.0	0.4
Bouteloua gracilis	blue grama	2 - 3	2.3	0.3
Berberis fremontii	barberry	1 - 3	1.8	0.3
Chamaebatiaria millefolium	fernbush	1 - 4	2.4	0.2
Opuntia whipplei	whipple cholla	1 - 3	1.5	0.2

Occasional Species: *Coryphantha vivipara, Agave utahensis, Amelanchier utahensis, Echinocereus triglochidiatus, Quercus gambelii, Opuntia erinacea, Atriplex canescens, Eriogonum corymbosum, Fallugia paradoxa, Penstemon linearioides, P. utahensis, Chrysothamnus viscidiflorus.*

Physiognomy: Evergreen needle-leaved and scale-leaved woodland in open stands. The understory is composed of evergreen shrubs, succulents and perennial bunch grasses. The trees are 15 to 25 feet (5 to 8 meters) tall and the shrubs are 1 to 6 feet (0.3 to 1.8 meters) tall. Estimated total cover ranges from 15 to 40 percent. *Chamaebatiaria millefolium* and *Coryphantha vivipara* are generally restricted to this association in the park (Fig. 9).

Figure 9. *Pinus edulis - Juniperus osteosperma -Artemisia tridentata - Cowania mexicana* (122.4145) near Pasture Wash. A low limestone ridge is shown where *Cowania mexicana* (foreground) and *Artemisia tridentata* appear in an opening surrounded by *Pinus edulis* and *Juniperus osteosperma.*

122.4146

Name: *Pinus edulis - Quercus turbinella - Arctostaphylos pungens* (Pinyon Pine - Scrub Oak - Manzanita)

Distribution: Elevational range is 5,000 to 8,000 feet (1,520 to 2,440 meters). The type is found on steep slopes of canyon walls and terraces and on narrow ledges. Soils are rocky, derived from limestone or sandstone. The type is widespread north of the river from the Shivwits Plateau to Nankoweap Valley.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (67)
Pinus edulis	pinyon pine	1 - 4	3.0	0.9
Quercus turbinella/ undulata	scrub oak	1 - 4	3.3	0.8
Arctostaphylos pungens	manzanita	2 - 5	3.5	0.7
Juniperus osteosperma	Utah juniper	1 - 5	2.9	0.8
Garrya flavescens	silk-tassle	1 - 4	2.8	0.5
Ephedra viridis	Mormon tea	1 - 4	2.3	0.6
Yucca baccata	banana yucca	1 - 4	2.2	0.6
Associated Species				
Gutierrezia sarothrae	snakeweed	1 - 4	2.4	0.5
Agave utahensis	Utah agave	1 - 3	2.0	0.5
Artemisia tridentata	big sagebrush	1 - 5	3.3	0.4
Amelanchier utahensis	serviceberry	1 - 4	2.8	0.4
Rhus trilobata	skunkbush	1 - 4	2.6	0.4
Cercocarpus montanus	mountain-mahogany	1 - 4	2.9	0.3
Glossopetalon nevadense	greasebush	2 - 4	2.7	0.3
Ceanothus greggii	deerbrush	1 - 4	2.6	0.3
Cowania mexicana	cliffrose	1 - 4	2.3	0.3
Cercocarpus intricatus	little-leaf mountain-mahogany	1 - 5	2.9	0.2
Opuntia phaeacantha	prickly-pear cactus	1 - 3	1.8	0.3

Occasional Species: *Fraxinus anomala, Artemisia ludoviciana, Opuntia erinacea, Echinocereus triglochidiatus, Ptelea trifoliata, Fallugia paradoxa, Thamnosma montana, Berberis fremontii, Robinia neomexicana, Fendlera rupicola, Quercus gambelii, Phlox austromontana.*

Physiognomy: Evergreen needle-leaved and scale-leaved woodland in open, irregularly spaced stands. Dense thickets of evergreen sclerophyllous shrubs and succulents are also present. Trees are 10 to 24 feet (3 to 8 meters) tall and shrubs are 2 to 6 feet (0.6 to 1.8 meters) tall. Estimated total cover is 30 to 60 percent. Floristic composition of the type varies between the Shivwits Plateau region and the Tapeats/Kaibab Plateau region, with *Garrya flavescens* occurring with higher prominence at Shivwits and *Cercocarpus intricatus* and *Glossopetalon nevadense* increasing in abundance to the east. Small areas of chaparral thickets without trees occur scattered throughout this association, but these are too small to map at the scale used for this project (Fig. 10).

Figure 10. *Pinus edulis - Quercus turbinella -Arctostaphylos pungens - Juniperus osteosperma* (122.4146) located in 209 mile Canyon on the east side of the Shivwits Plateau. The relatively dense cover of mixed chaparral and woodland species is characteristic of the type.

122.4147

Name: *Coleogyne ramosissima - Pinus edulis - Juniperus osteosperma* (Blackbrush - Pinyon Pine - Juniper)

Distribution: Elevational range is 3,800 to 6,200 feet (1,160 to 1,890 meters). The type occurs on larger terraces with slightly rolling terrain of all aspects. Soils are relatively deep accumulations of sandy texture, derived from the Supai Group and occasionally the Redwall Limestone or Hermit Shale. The type is best developed on the Esplanade terraces of the Sanup Plateau and the Tapeats Amphitheater, but it is also found south of the river between Fossil Bay and Havasupai Point and in a few small areas in Nankoweap Valley.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (42)
Coleogyne ramosissima	blackbrush	2 - 5	4.3	1.0
Pinus edulis	pinyon pine	1 - 4	3.5	0.9
Juniperus osteosperma	Utah juniper	1 - 4	2.7	0.9
Ephedra viridis	Mormon tea	1 - 3	2.3	1.0
Yucca baccata	banana yucca	2 - 3	2.5	0.8
Gutierrezia sarothrae	snakeweed	1 - 4	2.4	0.8
Agave utahensis	Utah agave	1 - 4	2.5	0.6
Quercus turbinella/ undulata	scrub oak	1 - 4	2.3	0.6
Chrysothamnus nauseosus	rabbitbrush	1 - 4	2.2	0.6
Associated Species				
Thamnosma montana	turpentine broom	1 - 3	1.7	0.5
Cowania mexicana	cliffrose	1 - 4	1.7	0.5
Glossopetalon nevadense	greasebush	1 - 4	2.8	0.3
Opuntia phaeacantha	prickly-pear cactus	1 - 3	2.1	0.4
Berberis fremontii	barberry	1 - 3	2.0	0.3
Rhus trilobata	skunkbush	1 - 3	2.0	0.3
Cercocarpus montanus	mountain-mahogany	2 - 4	3.0	0.2
Ceanothus greggii	deerbrush	1 - 3	2.2	0.2
Artemisia tridentata/ nova	sagebrush	1 - 3	2.0	0.2

Occasional Species: *Amelanchier utahensis, Arctostaphylos pungens, Echinocereus triglochidiatus, Nolina microcarpa, Bernardia incana, Atriplex canescens, Opuntia erinacea, Bouteloua curtipendula, Cordylanthus parviflorus, Eriogonum corymbosum, Fraxinus anomala, Aristida* sp., *Bromus rubens, Psilostrophe sparsiflora.*

Physiognomy: Evergreen needle-leaved and scale-leaved woodland in open stands. The understory is composed of evergreen sclerophyllous shrubs, evenly spaced, and succulents. Trees are 10 to 20 feet (3 to 6 meters) tall and shrubs are 1 to 4 feet (0.3 to 1.2 meters) tall. Estimated total cover ranges from 15 to 40 percent, with fairly uniform distribution except where rock outcrops interrupt the deeper soil (Fig. 11).

Figure 11. *Coleogyne ramosissima - Pinus edulis -Juniperus osteosperma - Ephedra viridis* type (122.4147) on the Esplanade in Tapeats Amphitheater. Patches of snow on the cliffs in the background (photo was taken in April) are on the north side of Powell Plateau located on slopes dominated by woodland with deciduous shrub thickets (122.4148). In the foreground *Coleogyne ramosissima* dominates the shrub stratum.

122.4148

Name: *Pinus edulis - Amelanchier utahensis - Quercus gambelii* (Pinyon Pine - Serviceberry - Gambel Oak)

Distribution: Elevational range is 5,200 to 8,000 feet (1,580 to 2,440 meters). The type is commonly restricted to steep protected talus and rocky slopes with northern aspects. Soils are rocky, derived from the Kaibab Limestone, Toroweap Formation and Coconino Sandstone. The type usually occurs as a narrow band shadowed by the upper canyon walls at the Shivwits Plateau, Mt. Emma, Kaibab Plateau and the South Rim.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (61)
Pinus edulis	pinyon pine	1 - 5	3.5	0.9
Amelanchier utahensis	serviceberry	2 - 5	3.3	0.8
Quercus gambelii	Gambel oak	1 - 5	3.7	0.7
Juniperus osteosperma	Utah juniper	1 - 5	2.5	0.7
Symphoricarpos spp.	snowberry	2 - 4	2.8	0.6
Associated Species				
Artemisia tridentata/ nova	sagebrush	1 - 4	2.6	0.5
Ephedra viridis	Mormon tea	1 - 4	2.0	0.5
Poa pratensis	bluegrass	2 - 3	2.5	0.4
Ribes spp.	gooseberry	1 - 4	2.1	0.4
Pseudotsuga menziesii	Douglas fir	1 - 4	2.3	0.3
Robinia neomexicana	New Mexican locust	1 - 4	3.6	0.3
Fendlera rupicola	fendlerbush	1 - 4	2.9	0.3
Ptelea trifoliata	hop-tree	1 - 4	2.5	0.3
Yucca baccata	banana yucca	1 - 3	1.9	0.3
Chrysothamnus viscidiflorus	rabbitbrush	1 - 3	1.8	0.3
Quercus turbinella/ undulata	scrub oak	1 - 4	3.0	0.2
Garrya flavescens	silk-tassle	1 - 4	2.8	0.2
Fendlerella utahensis	———	1 - 3	2.4	0.2
Cercocarpus montanus	mountain-mahogany	1 - 4	2.5	0.2
Cowania mexicana	cliffrose	1 - 3	2.3	0.2
Fraxinus anomala/ cuspidata	ash	1 - 3	2.0	0.2
Opuntia erinacea	grizzly-bear cactus	1 - 3	1.8	0.2
Agave utahensis	Utah agave	1 - 2	1.5	0.2
Berberis fremontii	barberry	1 - 2	1.5	0.2

Occasional Species: *Holodiscus dumosus, Berberis repens, Ostrya knowltoni, Rubus parviflorus, Sheperdia rotundifolia, Artemisia ludoviciana, Cercocarpus ledifolius, Pinus ponderosa, Acer negundo, Lathyrus* sp., *Rhus trilobata, Geranium caespitosum, Rosa arizonica.*

Physiognomy: Evergreen needle-leaved and scale-leaved woodland form an open overstory. The understory is composed of thickets of deciduous shrubs and small trees. Trees are 15 to 50 feet (5 to 15 meters) tall and shrubs are 3 to 8 feet (0.9 to 2.4 meters) tall. Estimated total cover is patchy, ranging from 30 to 80 percent. Included within this type are dense deciduous shrub thickets, with few or no trees, which are too small to map individually and which are surrounded by stands of shrubs and trees characteristic of the vegetation type. Several species are almost exclusively restricted to this association in the Park, including *Holodiscus dumosus*, *Rubus parviflorus* and *Ostrya knowltoni*.

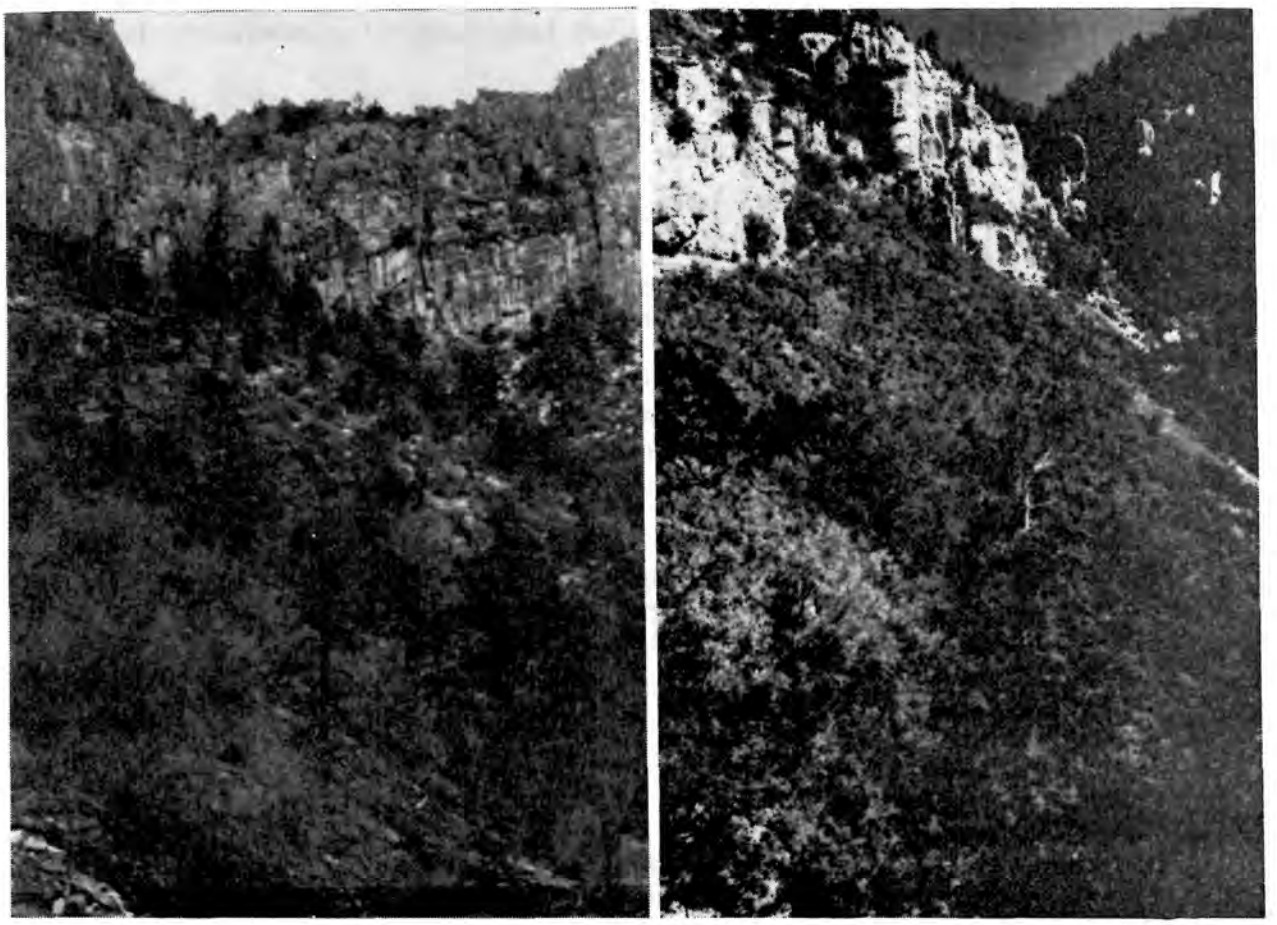


Figure 12. *Pinus edulis - Amelanchier utahensis - Quercus gambelii - Juniperus osteosperma* (122.4148) on the Grandview Trail, South Rim (left) and on the Bright Angel Trail, North Rim (right). This type is characterized by numerous deciduous shrub species which exhibit a striking seasonal variation in foliage condition from barren leaflessness in November (left) to luxuriant greenery in September (right).

122.4149

Name: *Pinus edulis - Juniperus osteosperma - Poa pratensis*
(Pinyon Pine - Juniper - Bluegrass)

Distribution: Elevational range is 6,400 to 7,000 feet (1,950 to 2,130 meters). The type is found on level terrrain. Soils are moderately deep, often gravelly with sandy loam texture, derived from the Kaibab Limestone. It is located on the South Rim and on Shiva Temple.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (18)
Pinus edulis	pinyon pine	3 - 5	4.2	1.0
Juniperus osteosperma	Utah juniper	3 - 5	3.7	1.0
Poa pratensis	bluegrass	3 - 4	3.2	0.8
Yucca baccata	banana yucca	1 - 3	2.4	0.7
Opuntia phaeacantha	prickly-pear cactus	1 - 3	1.8	0.7
Bouteloua gracilis	blue grama	1 - 3	2.1	0.6
Associated Species				
Artemisia tridentata	big sagebrush	1 - 2	1.6	0.5
Penstemon spp.	beard-tongue	1 - 2	1.3	0.5
Gutierrezia sarothrae	snakeweed	1 - 2	1.5	0.3
Coryphantha vivipara	———	1 - 2	1.5	0.2
Cowania mexicana	cliffrose	1 - 5	2.5	0.2
Astragalus sp.	locoweed	1 - 2	1.3	0.2
Lupinus cf. hillii	lupine	1 - 2	1.7	0.2
Eriogonum cf. jamesii	buckwheat	2	2.0	0.2

Occasional Species: *Chrysothamnus nauseosus, Quercus gambelii, Chrysothamnus viscidiflorus, Lesquerella* sp., *Penstemon barbatus, Penstemon pseudospectabilis, Ephedra viridis, Eriogonum wrightii, Cirsium* sp., *Bouteloua curtipendula, Lotus* sp., *Penstemon linearioides, Sporobolus cryptandrus, Townsendia* sp.

Physiognomy: Evergreen needle-leaved and scale-leaved woodland in evenly spaced stands. Understory is sparse, composed of perennial grass and occasional succulents and evergreen shrubs. Trees are 20 to 30 feet (6 to 9 meters) tall and grass and shrubs are less than 2 feet (less than 0.6 meters) tall. Estimated total cover ranges from 30 to 50 percent, having the highest tree cover of any *Pinus edulis Juniperus spp.* association in the park.

122.41410

Name: *Mortonia scabrella - Pinus edulis - Gutierrezia sarothrae* (Sandpaper bush - Pinyon Pine - Snakeweed)

Distribution: Elevational range is 3,500 to 5,000 feet (1,070 to 1,520 meters). This type is found on variable terrain of dissected bedrock terraces. Soils are shallow of sandy texture with gravel, derived from the Esplanade Sandstone. This type is found on the east side of the Shivwits Plateau from Kelly Point north to Parashant Canyon.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (11)
Mortonia scabrella	sandpaper bush	3 - 5	3.7	1.0
Pinus edulis	pinyon pine	3 - 4	3.5	1.0
Gutierrezia sarothrae	snakeweed	3 - 4	3.1	1.0
Juniperus osteosperma	Utah juniper	1 - 4	2.7	0.9
Ephedra viridis	Mormon tea	2 - 3	2.2	0.9
Agave utahensis	Utah agave	2 - 4	3.1	0.7
Coleogyne ramosissima	blackbrush	1 - 4	2.5	0.7
Quercus turbinella	scrub oak	3 - 4	3.4	0.6
Yucca baccata	banana yucca	2 - 3	2.8	0.6
Cowania mexicana	cliffrose	2 - 3	2.6	0.6
Opuntia erinacea	grizzly-bear cactus	2 - 3	2.3	0.6
Associated Species				
Ceanothus greggii	deer brush	3 - 4	3.4	0.5
Rhus trilobata	skunkbush	2 - 3	2.4	0.5
Dyssodia sp.	———	2 - 3	2.2	0.5
Thamnosma montana	turpentine broom	2 - 3	2.5	0.4
Yucca angustissima	datil	2 - 3	2.5	0.4
Eriogonum wrightii	buckwheat	1 - 3	2.0	0.4
Bernardia incana	———	1 - 3	1.8	0.4
Echinocereus engelmannii	hedgehog cactus	1 - 2	1.8	0.4
Parthenium incanum	mariola	2 - 3	2.3	0.3
Acacia greggii	catclaw acacia	1 - 3	2.0	0.3
Nolina microcarpa	bear grass	1 - 3	2.0	0.3
Opuntia phaeacantha	prickly-pear cactus	2 - 3	2.3	0.3
Chrysothamnus nauseosus	rabbitbrush	2 - 3	2.3	0.3

Occasional Species: *Eriogonum corymbosum, Penstemon utahensis, Cordylanthus parviflorus, Coldenia hispidissima, Psilostrophe sparsiflora, Cryptantha capitata, Cercocarpus montanus.*

Physiognomy: Evergreen needle-leaved and scale-leaved woodland in open stands. The understory is composed of evergreen sclerophyllous shrubs and scattered succulents. The trees are 10 to 15 feet (3 to 5 meters) tall. The shrubs are 1 to 4 feet (0.3 to 1.2 meters) tall. Estimated total cover ranges from 15 to 30 percent. Plants are distributed in rock crevices and soil pockets with extensive areas of bare sandstone slick-rock. This type is very similar to 122.4141, the major difference being a slightly more xeric aspect to the flora, resulting from the addition of *Mortonia scabrella*.

122.41411

Name: *Juniperus osteosperma - Pinus edulis - Ephedra viridis - Glossopetalon nevadense* (Juniper - Pinyon Pine - Mormon Tea - Greasebush)

Distribution: Elevational range is 3,200 to 7,200 feet (980 to 2,190 meters). The type is found on moderate to steep slopes and talus, generally of northerly aspects. Soils are coarse and rocky, derived from sandstone or limestone. This type is generally found on the south side of the inner canyon from Desert View to Fossil Bay.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (64)
Juniperus osteosperma	Utah juniper	1 - 5	3.4	0.9
Pinus edulis	pinyon pine	1 - 4	3.5	0.8
Ephedra viridis	Mormon tea	1 - 4	2.9	1.0
Glossopetalon nevadense	greasebush	1 - 4	3.1	0.7
Gutierrezia sarothrae	snakeweed	1 - 4	2.7	0.7
Yucca baccata	banana yucca	1 - 4	2.4	0.7
Agave utahensis	Utah agave	1 - 3	2.0	0.7
Artemisia tridentata/ nova	sagebrush	1 - 4	2.7	0.6
Chrysothamnus nauseosus	rabbitbrush	1 - 4	2.5	0.6
Associated Species				
Fendlera rupicola	fendlerbush	1 - 4	2.5	0.5
Amelanchier utahensis	serviceberry	1 - 4	2.7	0.4
Cowania mexicana	cliffrose	1 - 4	2.6	0.4
Opuntia erinacea	grizzly-bear cactus	1 - 3	2.1	0.4
Grasses (*Stipa, Bromus Poa*)		1 - 4	1.8	0.5
Thamnosma montana	turpentine broom	1 - 2	1.5	0.4
Ceanothus greggii	deerbrush	1 - 4	2.7	0.3
Fraxinus anomala	single-leaf ash	1 - 4	2.4	0.3
Cercocarpus intricatus	little-leaf mountain mahogany	1 - 4	2.4	0.3
Ptelea trifoliata	hop-tree	1 - 4	2.2	0.3
Yucca angustissima	datil	1 - 3	2.6	0.4
Rhus trilobata	skunkbush	1 - 4	2.1	0.2

Occasional Species: *Atriplex canescens, Phlox austromontanus, Cercocarpus montanus, Artemisia ludoviciana, Nolina microcarpa, Quercus turbinella, Eriogonum wrightii, Echinocereus engelmanni, Chrysothamnus viscidiflorus, Eriogonum corymbosum, Sheperdia rotundifolia, Fallugia paradoxa, Fendlerella utahensis.*

Physiognomy: Evergreen needle-leaved and scale leaved woodland in open stands. The understory is composed of evergreen sclerophyllous shrubs and scattered deciduous shrubs and succulents. Trees are 10 to 20 feet (3 to 6 meters) tall and shrubs are 1 to 6 feet (0.3 to 1.8 meters) tall. Estimated total cover ranges from 15 to 40 percent, with higher cover on more stable slopes. This type is very similar to 122.4142, differing mainly in the prominence of *Glossopetalon nevadense* and in the lack of *Quercus turbinella* (Fig. 13).

Figure 13. *Juniperus osteosperma - Pinus edulis - Ephedra viridis - Glossopetalon nevadense* (122.41411) on the Grandview Trail above Horseshoe Mesa. *J. osteosperma* and *P. edulis* are shown along with a variety of xeromorphic shrubs, the relative abundance of which change with slope aspect.

133.3111

Name: *Quercus turbinella - Arctostaphylos pungens* (Scrub Oak - Manzanita)

Distribution: Elevational range is 4,100 to 5,400 feet (1,250 to 1,640 meters). This type is restricted to extremely steep slopes (up to 60 percent) of variable aspects. The substrate is extremely weak shale with rapid downslope movement, making soil formation nearly impossible. Soils are derived from the Kwagunt Formation of the Grand Canyon Series. The type is found at Nankoweap Butte and occurs in patches too small to map in Nankoweap Valley.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (3)
Quercus turbinella	scrub oak	5	5.0	1.0
Arctostaphylos pungens	manzanita	1 - 3	2.0	1.0
Associated Species				
Bromus rubens	red brome	3	3.0	0.3
Yucca baccata	banana yucca	2	2.0	0.3
Opuntia phaeacantha	prickly-pear cactus	2	2.0	0.3
Opuntia erinacea	grizzly-bear cactus	2	2.0	0.3
Encelia frutescens	rayless encelia	2	2.0	0.3

Occasional Species: *Juniperus osteosperma, Coleogyne ramosissima, Pinus edulis, Bromus tectorum.*

Physiognomy: Evergreen sclerophyllous scrubland in extremely open stands. Annual grasses, succulents, sclerophyllous shrubs or evergreen needle-leaved or scale-leaved trees are present only where slope angles are less steep. Height of shrubs is up to 6 feet (1.8 meters) tall. Estimated total cover ranges from less than 1 to 10 percent. On the steepest slopes only *Quercus turbinella* and *Arctostaphylos pungens* are present, these appearing to be very old, having massive gnarled and twisted trunks. The type is relatively barren with no apparent reproduction on the steepest slopes.

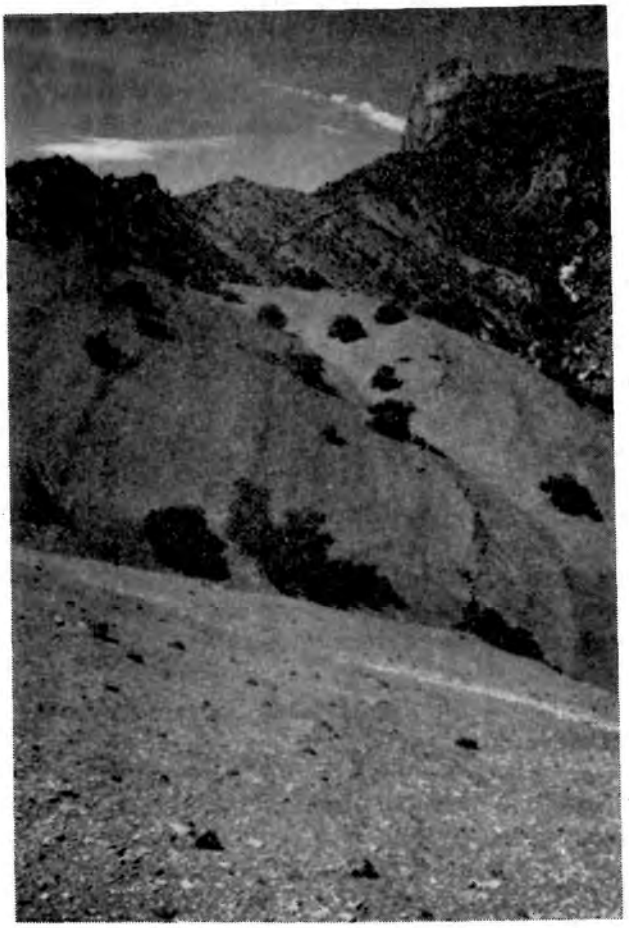


Figure 14. *Quercus turbinella* - *Arctostaphylos pungens* (133.3111) near Nankoweap Butte. These shrubs are widely scattered, and no other vegetation can be seen growing on the loose, unstable substrate.

Grasslands

Grassland communities occur in only three areas in the park, the North Rim, Toroweap Valley and above the Grand Wash Cliffs in the extreme southwest corner of the park. Mountain meadows on the North Rim are found in valley bottoms and sinkholes. These meadows contain a large number of grass species, with sedges usually dominating in the wettest areas and herbs mixed with grasses in the dry margins.

Semi-desert shrub-grasslands that are found in Toroweap Valley and the South Grand Wash Cliffs area are characterized by a variety of small perennial bunch grasses such as big galleta, blue grama, black grama, Indian ricegrass, three-awn and others. Associated with these grasses are several shrubs and half-shrubs, such as winterfat and wolfberry. Toroweap Valley has been heavily disturbed by livestock grazing resulting in thick stands of cheatgrass and lesser amounts of tumbleweed.

Descriptions of the three grassland associations used as mapping units at Grand Canyon follow here.

142.2511

Name: *Hilaria rigida - Bromus tectorum - Gutierrezia sarothrae* (Hilaria - Cheatgrass - Snakeweed)

Distribution: Elevational range is 3,800 to 4,700 feet (1,160 to 1,430 meters). This type is found on level to gently rolling terrain of all aspects. Soils are shallow and cobbly, derived from basalt or consolidated alluvium. The type occurs in Toroweap Valley and on the lava flow in Tuckup Canyon.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (13)
Hilaria rigida	big galleta	2 - 5	3.7	0.8
Bromus tectorum	cheatgrass	2 - 5	3.8	0.8
Gutierrezia sarothrae	snakeweed	2 - 5	3.4	0.8
Atriplex canescens	four-wing saltbush	1 - 4	2.3	0.7
Eurotia lanata	winterfat	1 - 3	2.0	0.7
Lycium pallidum	wolfberry	2 - 4	3.0	0.5
Associated Species				
Opuntia whipplei	whipple cholla	1 - 3	1.5	0.5
Salsola kali	tumbleweed	1 - 2	1.7	0.5
cf. Muhlenbergia sp.	muhly	2 - 4	3.2	0.4
Aristida sp.	three-awn	2 - 4	3.0	0.4
Ephedra viridis	Mormon tea	2 - 3	2.8	0.3
Plantago insularis	plantain	2 - 3	2.3	0.3
Oryzopsis hymenoides	Indian ricegrass	2	2.0	0.2
Yucca baccata	banana yucca	2	2.0	0.2
Eriogonum inflatum	desert trumpet	2 - 3	2.5	0.2

Occasional Species: *Opuntia phaeacantha, Cleome lutea, Coryphantha* sp., *Opuntia erinacea, Artemisia tridentata, Stipa* sp., *Bouteloua* sp.

Physiognomy: Perennial and annual mixed grassland. Mixed evergreen sclerophyllous and deciduous shrubs, succulents and annual or perennial herbs are also common. Tallest height of shrubs is 3 feet (0.9 meters). Estimated total cover is less than 50 percent even during peak seasons for annual grasses.

Figure 15. *Hilaria rigida - Bromus tectorum - Gutierrezia sarothrae* (142.2511) in Toroweap Valley. This is the most extensive grassland in the park but it is heavily disturbed by years of grazing as indicated by the prominence of invading species such as *Bromus rubens* and *Gutierrezia sarothrae*.

142.411

Name Mixed Meadow Series

Distribution: Elevational range is 7,800 to 9,100 feet (2,380 to 2,770 meters). This type is found on low slopes or level terrain in drainage depresssions or sinkholes. Soils are well developed and deep of loamy texture, derived from the Toroweap Formation and Kaibab Limestone. The type occurs throughout the North Rim.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (23)
Grasses (*Stipa lettermani, Muhlenbergia montana, Agropyron subsecundum, Bromus marginatus, Phleum pratense, Dactylis glomerata, Koeleria cristata, Sitanion hystrix, Blepharoneuron tricholepis, Bouteloua gracilis, Deschampsia caespitosa*)		3 - 5	3.7	0.9
Poa pratensis	bluegrass	3 - 4	3.4	0.7
Senecio sp.	groundsel	2 - 3	2.7	0.6
Achillea lanulosa	yarrow	2 - 3	2.7	0.6
Potentilla spp. (*P. glandulosa, P. hippiana, P. norvegica*)	cinquefoil	1 - 4	2.7	0.6
Associated Species				
Lupinus hillii	lupine	3 - 4	3.1	0.5
Eriogonum racemosum	buckwheat	3	3.0	0.5
Carex spp. (*C. occidentalis, C. subfusa*)	sedge	2 - 4	3.3	0.5
Aster spp.	aster	2 - 3	2.6	0.5

Occasional Species: *Agastache pallidiflora, Agoseris glauca, Arenaria fendleri, Artemisia caruthii, Artemisia dracunculoides, Artemisia pacifica, Aster foliaceous, Calamagrostis* sp., *Campanula parryi, Carex subfusa, Castilleja confusa, Collimia linearis, Chrysopsis villosa, Danthonia intermedia, Deschampsia caespitosa, Epilobium californicum, Erigeron flagellaris, Eriogonum racemosum, Erysimum repandum, Gentiana strictiflora, Gilia tenuituba, Helianthella quinquenervis, Hypericum formosum, Linum lewesii, Madia glomerata Mentha arvensis, Mertensia franciscana, Orthocarpus luteus, Orthocarpus purpureo-albus, Oxybaphus comatus, Penstemon virgatus, Perideridia parishii, Phacelia magellanica, Polygonum douglasii, Polygonum*

sawatchense, Pseudocymopterus montanus, Ranunculus cardiophyllus, Rumex acetosella, Rumex californicus, Salix bebbiana, Solidago ciliosa, Trifolium pinetorum, Trisetum montanum, Viguiera multiflora.

(Note: Species listed in this description were collected or recorded during field trips to the North Rim in August and September, 1978. This should be considered as a partial list of species present in meadows during the late summer season.)

Physiognomy: Mixed meadow of grasses and herbs. Vegetation is less than 1.5 feet (0.5 meters) tall. Total estimated cover ranges from 35 percent to as high as 100 percent at some locations. Grasses as a whole constitute the prominent aspect of the type but the grass species present may vary from meadow to meadow. Small meadows are frequently isolated from one another. Some plant species may be restricted to only one meadow. Principal factors affecting distribution of species within the meadows are drainage and moisture availability. Species tending to inhabit moist drainage depressions are *Carex spp.* and grasses, while a great diversity of herbs occur on well drained meadow margins. It may be possible to differentiate the variability of these associations on a larger scale map. *Populus tremuloides* and *Picea engelmannii* normally surround the meadows.

Figure 16. Montane mixed meadow (142.411) in Marble Flats near the North Rim Village. Note the zonation related to soil moisture, from the central wettest area (left center) dominated by sedges through an intermediate grass-dominated zone to the driest forb-dominated margin (right foreground). The hill in the background has *Populus tremuloides* at the bottom near the meadow margin and *Pinus ponderosa* on the level top.

143.1131

Name: *Bouteloua eriopoda - Gutierrezia sarothrae - Eurotia lanata* (Black Grama - Snakeweed - Winterfat)

Distribution: Elevational range is 4,700 to 5,200 feet (1,430 to 1,580 meters). This type is found in level swales (slope less than 2 percent). Soil is silty loam derived from Kaibab Limestone. This type is found only on top of the Grand Wash Cliffs in the extreme southwestern part of the park.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (6)
Bouteloua eriopoda	black grama	3 - 4	3.8	0.8
Gutierrezia sarothrae	snakeweed	2 - 4	3.1	1.0
Eurotia lanata	winterfat	1 - 4	2.0	0.8
Atriplex canescens	four-wing saltbush	2 - 3	2.5	0.6
Sphaeralcea sp.	mallow	1 - 2	1.5	0.6
Bromus rubens	red brome	3 - 4	3.3	1.0
Associated Species				
Aristida fendleriana	three-awn	1 - 3	2.3	0.5
Coleogyne ramosissima	blackbrush	2 - 3	2.3	0.5
Hilaria rigida	big galleta	4	4.0	0.3
Scleropogon brevifolia	burrograss	4	4.0	0.3
Lycium andersoni	wolfberry	1 - 2	1.6	0.5
Aster hirsuta	aster	2	2.0	0.3
Oryzopsis hymenoides	Indian ricegrass	1 - 2	1.5	0.3
Erioneuron pulchellum	desert fluffgrass	1 - 2	1.5	0.3

Occasional Species: *Bouteloua gracilis, Sporobolus* sp., *Lycium pallidum, Yucca brevifolia, Ephedra viridis, Menodora scoparia, Opuntia acanthocarpa.*

Physiognomy: Grassland with evergreen and deciduous shrubs and half-shrubs. Height of the grasses is less than 1 foot (0.3 meters) and height of shrubs is less than 3 feet (0.9 meters). Estimated total ground cover is 15 to 30 percent. The various grass species tend to occur in segregated patches. This type has the best representation of native grasses of any grassland area in the park.

Cold Desertscrub

Communities of cold-desert plants characteristic of the Great Basin Desert are found on top of the plateaus surrounding the canyon and on some of the higher elevation slopes and terraces of the inner canyon. For the most part, Great Basin desertscrub associations fall into one of three groups: those dominated by big sagebrush, blackbrush, or saltbush. In general, sagebrush associations are found on the plateaus, while blackbrush associations are found on terraces within the canyon. Saltbush associations are found on plateaus and in the canyon. In all locations, Great Basin desertscrub commonly occurs in association with pinyon-juniper woodland, and frequently the two formations share many species.

Big sagebrush is usually confined to heavier soils of swales and valley bottoms, but is also found in extensive stands on volcanic flows in Toroweap Valley. Sagebrush stands within the park usually have low species diversity, frequently with only two or three woody associated species. Grasses, particularly western wheatgrass, blue grama and Indian ricegrass, are often important in sagebrush flats. At the rim edge, especially in the Cape Solitude area, black sagebrush may replace big sagebrush as the dominant species, and in some locations the gradation in size between the two species makes them difficult to tell apart.

Those blackbrush-dominated desertscrub associations which are found above 4,000 feet (above the Tonto Platform) on terraces and moderate slopes of the inner canyon are classified as Great Basin desertscrub. On sites with deep soil, blackbrush may occur in almost pure stands with only a few associated species including Mormon tea, banana yucca and snakeweed. On rocky terraces such as portions of the Esplanade, the water-catchment effect of bedrock surfaces permits growth of plants with more mesic habitat requirements, resulting in a diverse mixture of Great Basin desertscrub species and chaparral and woodland shrubs.

Associations characterized by four-wing saltbush are found in Toroweap Valley and near Cape Solitude. Saltbush is also a dominant species in small scattered pockets of silty soil on the Esplanade. At a few sites, saltbush is an important codominant found with winterfat or sagebrush. Saltbush is usually a dominant in swales and flats with heavy, silty soil; but it can occur as an associated species on almost every kind of soil.

Descriptions of the twelve cold desertscrub associations used as mapping units at Grand Canyon follow here.

152.1111

Name: *Artemisia tridentata - Gutierrezia sarothrae - Bouteloua gracilis* (Big Sagebrush - Snakeweed - Blue Grama)

Distribution: Elevational range is 4,500 to 6,700 feet (1,370 to 2,040 meters). This type is found on flat valley bottoms and drainage depressions, and on low, rolling hills of plateau tops. Soil is moderately deep, fine textured alluvium which usually is derived from limestone or volcanic flows. This type is found at Toroweap Valley, Kanab Plateau, South Rim, Pasture Wash and Desert View.

Floristics:

Characteristic Species		**Prominence** Range	Mean	**Frequency** (19)
Artemisia tridentata	big sagebrush	5	5.0	1.0
Gutierrezia sarothrae	snakeweed	1 - 3	2.3	0.7
Bouteloua gracilis	blue grama	2 - 4	2.8	0.5
Associated Species				
Juniperus osteosperma	Utah juniper	1 - 4	2.0	0.5
Agropyron smithii	Western wheatgrass	2 - 4	2.8	0.3
Chrysothamnus viscidiflorus	rabbitbrush	2 - 3	2.6	0.3
Poa sp.	bluegrass	1 - 3	2.4	0.3
Atriplex canescens	four-wing saltbush	1 - 3	1.6	0.3
Ephedra viridis	Mormon tea	2 - 3	2.3	0.2
Oryzopsis hymenoides	Indian ricegrass	1 - 2	1.7	0.2

Occasional Species: *Opuntia whipplei, Atriplex confertifolia, Pinus edulis, Berberis fremontii, Yucca baccata, Cowania mexicana, Eriogonum wrightii, Linum lewisii, Chrysothamnus nauseosus, Artemisia dracunculoides, Castilleja lanata, Eriogonum mearnsii.*

Physiognomy: Evergreen, microphyll desertscrub with half-shrubs, grasses and scattered succulents. Evergreen, coniferous trees may encroach on the margins of *Artemisia* flats. Height of all shrubs is less than 3 feet (0.9 meters). Estimated total ground cover ranges from 20 to 45 percent and is evenly distributed (Fig. 17).

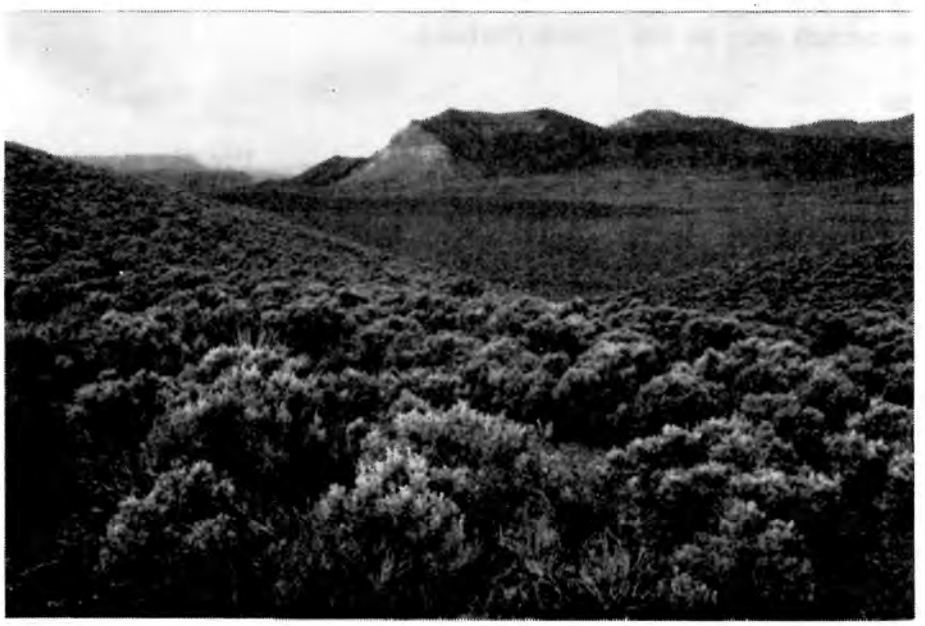


Figure 17 *Artemisia tridentata - Gutierrezia sarothrae - Bouteloua gracilis* (152.1111) on lava flows near Vulcan's Throne. In the stand shown *A. tridentata* is extensive and other species are much less common.

152.1112

Name: *Artemisia tridentata - Juniperus osteosperma - Pinus edulis* (Big Sagebrush - Juniper - Pinyon Pine)

Distribution: Elevational range is 5,500 to 6,300 feet (1,680 to 1,920 meters). This type is found on gently sloping or rolling terrain of plateau tops which are dissected by drainages near the rim edge. Soil is derived from Kaibab Limestone. This type occurs only on the Kanab Plateau.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (13)
Artemisia tridentata	big sagebrush	3 - 5	3.9	1.0
Juniperus osteosperma	Utah juniper	2 - 4	3.0	0.8
Pinus edulis	Pinyon pine	1 - 4	2.6	0.8
Ephedra viridis	Mormon tea	2 - 3	2.7	0.7
Cowania mexicana	cliffrose	1 - 3	2.0	0.6
Associated Species				
Yucca baccata	banana yucca	2 - 3	2.2	0.5
Opuntia erinacea	grizzly-bear cactus	1 - 3	2.0	0.4
Shepherdia rotundifolia	buffaloberry	1 - 2	1.6	0.4
Atriplex canescens	four-wing saltbush	1 - 3	1.6	0.4
Berberis fremontii	barberry	2 - 3	2.7	0.3
Agave utahensis	Utah agave	2 - 3	2.2	0.3

Occasional Species: *Opuntia whipplei, Fallugia paradoxa, Coryphantha* sp., *Echinocereus triglochidiatus, Eurotia lanata, Bouteloua gracilis, Bromus rubens, Stipa comata, Mirabilis multiflora, Ptelea trifoliata, Rhus trilobata.*

Physiognomy: Evergreen microphyll desertscrub with sub-shrubs, grasses, succulents and scattered evergreen, coniferous trees. Height of all shrubs is less than 3 feet (0.9 meters) and height of trees is 10 to 20 feet (3 to 6 meters). Estimated total ground cover is 15 to 35 percent. This type is similar to the woodland types 122.4144 and 122.4145, but can be distinguished because *Artemisia tridentata* is clearly more prominent than *Pinus edulis* and *Juniperus osteosperma.*

152.1121

Name: *Artemisia tridentata - Gutierrezia sarothrae - Ephedra viridis* (Big Sagebrush - Snakeweed - Mormon Tea)

Distribution: Elevational range is 3,800 to 6,200 feet (1,160 to 1,890 meters). This type is found on moderate to steep slopes of all aspects in the inner canyon. Soils are thin and rocky and may be derived from Kaibab Limestone, Toroweap Formation, Coconino Sandstone and volcanic flows. This type is restricted to the Kanab Plateau area north of the river.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (16)
Artemisia tridentata	big sagebrush	3 - 5	3.9	0.8
Gutierrezia sarothrae	snakeweed	2 - 4	3.1	0.8
Ephedra viridis	Mormon tea	1 - 4	3.0	0.6
Berberis fremontii	barberry	1 - 3	2.1	0.6
Associated Species				
Fallugia paradoxa	Apache plume	2 - 3	2.4	0.5
Juniperus osteosperma	Utah juniper	1 - 3	2.0	0.4
Shepherdia rotundifolia	buffaloberry	2 - 4	2.7	0.4
Rhus trilobata	skunkbush	1 - 4	2.4	0.3
Pinus edulis	pinyon pine	1 - 3	2.3	0.2
Ptelea trifoliata	hop-tree	1 - 4	2.2	0.2
Cowania mexicana	cliffrose	1 - 3	2.0	0.2
Agave utahensis	Utah agave	1 - 2	1.3	0.2
Thamnosma montana	turpentine broom	2 - 3	2.3	0.2
Yucca baccata	banana yucca	1 - 3	2.0	0.2
Atriplex canescens	four-wing saltbush	3	3.0	0.2
Nolina microcarpa	beargrass	1 - 3	2.5	0.2

Occasional Species: *Amelanchier utahensis, Opuntia chlorotica, Echinocereus triglochidiatus, Opuntia phaeacantha, Quercus turbinella, Eriogonum corymbosum, Chrysothamnus* sp.

Physiognomy: Evergreen, microphyll desertscrub with half-shrubs, deciduous shrubs and scattered succulents. Height of shrubs is generally less than 3 feet (0.9 meters) but occasionally reaches 6 feet (1.8 meters) in *Cowania* and *Berberis*. Estimated total cover ranges from 10 to 30 percent, and may reach 50 percent in protected locations. Species composition varies with aspect, with more deciduous species on north-facing slopes.

152.1141

Name: *Artemisia tridentata - Atriplex canescens - Ephedra viridis* (Big Sagebrush - Saltbush - Mormon Tea)

Distribution: Elevational range is 5,800 to 6,700 feet (1,770 to 2,040 meters). This type is found in drainages or on lower slopes no greater than 8 percent. Soil is loamy alluvium or thin and gravelly on hillsides and derived from Kaibab Limestone. This type is restricted to the plateau top in the Cape Solitude area.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (7)
Artemisia tridentata	big sagebrush	4 - 5	4.4	1.0
Atriplex canescens	four-wing saltbush	3 - 4	3.8	1.0
Ephedra viridis	Mormon tea	3 - 4	3.2	1.0
Gutierrezia sarothrae	snakeweed	2 - 3	2.7	0.6
Associated Species				
Opuntia whipplei	grizzly-bear cactus	1 - 3	2.0	0.4
Opuntia sp.	———	1	1.0	0.3
Lycium pallidum	wolfberry	1	1.0	0.2
Oryzopsis hymenoides	Indian ricegrass	3	3.0	0.2
Yucca baccata	banana yucca	2	2.0	0.2

Occasional Species: *Chrysothamnus greenii, Fallugia paradoxa, Chamaebatiaria millefolium, Eriogonum mearnsii, Juniperus monosperma, Sitanion hystrix, Bromus tectorum, Eurotia lanata.*

Physiognomy: Evergreen microphyll desertscrub with half-shrubs and succulents. Height of shrubs is less than 3 feet (0.9 meters). Estimated total cover ranges from 20 to 30 percent. This type differs from 152.1142 mainly because *Artemisia tridentata* replaces *A. nova* as the dominant species.

152.1142

Name: *Artemisia nova - Atriplex canescens - Ephedra viridis* (Black Sagebrush - Saltbush - Mormon Tea)

Distribution: Elevational range is 5,800 to 6,200 feet (1,770 to 1,890 meters). This type is found on gentle to moderate slopes (2 to 23 percent) with little dissection. Soils are gravelly or rocky and are derived from Kaibab Limestone. This type is found near the rim edge in the Cape Solitude area. This type occurs closer to the rim than the similar type 152.1141.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (10)
Artemisia nova	black sagebrush	3 - 5	4.8	1.0
Atriplex canescens	four-wing saltbush	2 - 4	3.4	1.0
Ephedra viridis	Mormon tea	3 - 4	3.1	1.0
Eurotia lanata	winterfat	3 - 4	3.1	0.7
Oryzopsis hymenoides	Indian ricegrass	2 - 4	2.3	0.7
Yucca baccata	banana yucca	1 - 3	2.0	0.7
Castilleja cf. confusa	Indian paintbrush	2 - 3	2.3	0.7
Opuntia phaeacantha	prickly-pear cactus	1 - 2	1.6	0.8
Associated Species				
Gutierrezia sarothrae	snakeweed	2 - 3	2.5	0.6
Chrysothamnus viscidiflorus	rabbitbrush	1 - 3	1.8	0.5
Bouteloua gracilis	blue grama	2 - 3	2.2	0.5
Phlox austromontana	———	2 - 3	2.2	0.5
Juniperus osteosperma	Utah juniper	2 - 3	2.5	0.4
Opuntia whipplei	grizzly-bear cactus	1	1.0	0.3
Sitanion hystrix	squirrel tail	2	2.0	0.2

Occasional Species: *Lycium* sp., *Artemisia bigelovii, Poa fendleri, Polygala subspinosa, Cowania mexicana, Echinocereus triglochidiatus, Cercocarpus intricatus, Fallugia paradoxa, Agave utahensis.*

Physiognomy: Dwarf evergreen microphyll desertscrub with half-shrubs and scattered succulents. Height of all shrubs is less than 2 feet (0.6 meters). Estimated total cover ranges from 10 to 20 percent and plants are uniformly spaced.

152.1311

Name: *Coleogyne ramosissima - Ephedra viridis - Yucca baccata* (Blackbrush - Mormon Tea - Banana Yucca)

Distribution: Elevational range is 3,900 to 5,300 feet (1,190 to 1,610 meters). This type is found on terraces of the Esplanade Sandstone and Redwall Limestone and adjacent gentle to moderate hillslopes. Soils are usually sandy and often occur as a mantle or pocket overlying bedrock terraces. This type occurs throughout the canyon at scattered localities, but is most common in Tapeats Amphitheater and Aztec Amphitheater.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (38)
Coleogyne ramosissima	blackbrush	4 - 5	4.2	1.0
Yucca baccata	banana yucca	1 - 3	2.5	0.9
Ephedra viridis	Mormon tea	1 - 3	2.3	0.9
Agave utahensis	Utah agave	1 - 3	2.5	0.6
Gutierrezia sarothrae	snakeweed	1 - 3	2.2	0.6
Associated Species				
Chrysothamnus viscidiflorus	rabbitbrush	1 - 3	1.9	0.5
Atriplex canescens	four-wing saltbush	1 - 3	2.2	0.4
Opuntia phaeacantha	prickly-pear cactus	1 3	2.3	0.4
Opuntia erinacea	grizzly-bear cactus	1 - 3	2.4	0.4
Juniperus monosperma	one-seed juniper	1 - 3	1.8	0.3
Bromus rubens	red brome	3 - 5	2.3	0.3
Echinocereus triglochidiatus	hedgehog cactus	1	1.0	0.3
Cowania mexicana	cliffrose	2 - 3	2.2	0.3

Occasional Species: *Pinus edulis, Artemisia tridentata, Eriogonum inflatum, Berberis fremontii, Eurotia lanata, Acacia greggii, Quercus turbinella, Eriogonum corymbosum, Rhus trilobata, Mirabilis multiflora, Sphaeralcea* sp., *Thamnosma montana, Tiquilia latior, Fallugia paradoxa.*

Physiognomy: Evergreen microphyll desertscrub with succulents and half-shrubs. Height of all shrubs is less than 3 feet (0.9 meters) with the exception of *Cowania* which may reach 6 feet (1.8 meters). Estimated total ground cover is 15 to 30 percent and is evenly distributed. Introduced annual grasses may be locally abundant creating a range fire hazard during the dry season (Fig 18).

Figure 18. *Coleogyne ramosissima - Ephedra viridis -Yucca baccata* (152.1311) on the Esplanade of Darwin Plateau. Stands of *C. ramosissima* such as this occur in a mosaic pattern, surrounded by woodlands of *Pinus edulis* and *Juniperus osteosperma.*

152.1421

Name: *Chrysothamnus viscidiflorus - Gutierrezia sarothrae - Atriplex canescens* (Rabbitbrush - Snakeweed - Four-wing Saltbush)

Distribution: Elevational range is 3,500 to 4,500 feet (1,070 to 1.370 meters). This type is found on level to rolling terrain with gentle slopes of all aspects. Soil is cobbly and usually derived from volcanic flows, but it may be derived from Esplanade Sandstone. This type is restricted to Toroweap Valley and the immediate vicinity.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (4)
Chrysothamnus viscidiflorus	rabbitbrush	3 - 5	4.3	1.0
Gutierrezia sarothrae	snakeweed	3 - 4	3.5	1.0
Atriplex canescens	four-wing saltbush	2 - 3	2.3	1.0
Yucca baccata	banana yucca	2 - 3	2.5	1.0
Ephedra nevadense	Mormon tea	2	2.0	0.8
Opuntia erinacea	grizzly-bear cactus	2	2.0	0.8
Artemisia tridentata	big sagebrush	2	2.0	0.8
Associated Species				
Lycium andersonii	wolf-berry	4	4.0	0.5
Hilaria rigida	big galleta	3	3.0	0.5
Bouteloua gracilis	blue grama	3	3.0	0.5
Eriogonum inflatum	desert trumpet	1 - 3	2.0	0.5
Glossopetalon nevadense	greasebush	4	4.0	0.2

Occasional Species: *Eurotia lanata, Muhlenbergia* sp., *Eriogonum corymbosum, Psilostrophe sparsiflorus, Chrysothamnus nauseosus, Thamnosma montana, Rhus trilobata, Cowania mexicana, Berberis fremontii, Ephedra viridis.*

Physiognomy: Deciduous microphyll desertscrub composed of half-shrubs with evergreen microphyll shrubs, succulents and grasses. Height of all species is less than 2 feet (0.6 meters). Estimated total ground cover is 15 to 25 percent. Introduced annual grasses may be locally abundant.

152.1531

Name: *Eurotia lanata - Atriplex canescens - Ephedra viridis*
(Winterfat - Four-wing Saltbush - Mormon Tea)

Distribution: Elevational range is 5,900 to 6,300 feet (1,800 to 1,920 meters). This type is found in swales with less than 1 percent slope. Soil is fine textured alluvium derived from Kaibab Limestone. The type is found only in the Cape Solitude area.

Floristics:

Characteristic Species		**Prominence** Range	Mean	**Frequency** (5)
Eurotia lanata	winterfat	4 - 5	4.4	1.0
Atriplex canescens	four-wing saltbush	3 - 4	3.8	1.0
Ephedra viridis	Mormon tea	2 - 3	2.7	1.0
Oryzopsis hymenoides	Indian ricegrass	2 - 4	2.7	1.0
Gutierrezia sarothrae	snakeweed	1 - 3	2.0	0.6
Associated Species				
Artemisia nova	black sagebrush	2	2	0.4
Opuntia sp.	———	1	1	0.4
Chrysothamnus spp.	rabbitbrush	1	1	0.2

Occasional Species: *Lycium* sp., *Erodium cicutarium, Hilaria rigida, Bouteloua gracilis, Phlox austromontana.*

Physiognomy: Evergreen microphyll desertscrub composed of half-shrubs and shrubs with scattered succulents and grasses. Height of all plants is less than 2 feet (0.6 meters). Estimated total ground cover ranges from 20 to 30 percent but distribution of species within the type is often patchy.

152.1621

Name: *Quercus turbinella - Gutierrezia sarothrae - Nolina microcarpa - Coleogyne ramosissima* (Scrub Oak - Snakeweed - Beargrass - Blackbrush)

Distribution: Elevational range is 3,200 to 5,600 feet (980 to 1,710 meters). This type is found on dissected bedrock terraces of the Esplanade. It occurs as patches in fractures and sandy soil pockets derived from Esplanade Sandstone and the Wescogame Formation, interspersed with large expanses of bare rock. This type is found from Tuckup Canyon to Bridger's Knoll on the north side of the river and from National Canyon to Fossil Bay on the south side.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (33)
Quercus turbinella	scrub oak	1 - 4	3.1	0.9
Gutierrezia sarothrae	snakeweed	1 - 5	2.6	0.9
Nolina microcarpa	bear-grass	2 - 4	2.9	0.6
Coleogyne ramosissima	blackbrush	1 - 4	2.9	0.6
Shepherdia rotundifolia	buffaloberry	1 - 3	2.1	0.6
Cercocarpus intricatus	mountain mahogany	3	3.0	0.6
Rhus trilobata	skunkbush	1 - 3	2.4	0.6
Associated Species				
Yucca angustissima	———	1 - 3	2.2	0.5
Ceanothus greggii	desert deerbrush	1 - 3	2.0	0.5
Yucca baccata	banana yucca	1 - 3	2.1	0.5
Pinus edulis	pinyon pine	1 - 3	2.1	0.4
Chrysothamnus sp.	rabbitbrush	1 - 3	2.3	0.4
Artemisia sp.	sagebrush	1 - 3	2.3	0.4
Acacia greggii	catclaw acacia	1 - 3	1.8	0.4
Juniperus osteosperma	Utah juniper	1 - 3	1.7	0.4
Thamnosma montana	turpentine broom	1 - 3	2.0	0.4

Occasional Species: *Echinocereus triglochidiatus, Bernardia incana, Tiquilia latior, Fraxinus anomala, Berbris fremontii, Atriplex canescens, Ferocactus wislizenii, Fallugia paradoxa, Eriogonum corymbosum, Mortonia scabrella, Eurotia lanata, Amelanchier utahensis.*

Physiognomy: Mixed evergreen sclerophyll and microphyll desertscrub with scattered deciduous shrubs and succulents. Height of shrubs is up to 5 feet (1.5 meters) and many succulents are 1 to 2 feet (0.3 to 0.6 meters) tall. Estimated total cover is 10 to 25 percent, but plants are patchy with dense clumps separated by nonvegetated bedrock. Slick-rock surfaces act as water catchments permitting the growth of relatively mesic species in exposed sites. Diversity of associated and occasional species is high and is quite variable from site to site within the type (Fig. 19).

Figure 19. *Quercus turbinella - Gutierrezia sarothrae -Nolina microcarpa - Coleogyne ramosissima* (152.1621) on the Esplanade near the northeast tip of the Great Thumb. Many chaparral and woodland species are mixed with desertscrub species here because rainwater runoff from the rock terraces makes more water available in cracks and soil pockets than is normally available at this elevation.

152.1721

Name: *Atriplex canescens - Artemisia tridentata - Gutierrezia sarothrae* (Four-wing Saltbush - Big Sagebrush - Snakeweed)

Distribution: Elevational range is 4,200 to 4,500 feet (1,280 to 1,370 meters). This type occurs on level floodplains and valley bottoms. Soil is silty loam which is subject to flooding and is frequently dissected. This type is found only in Toroweap Valley.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (3)
Atriplex canescens	four-wing saltbush	2 - 4	3.3	1.0
Artemisia tridentata	big sagebrush	3 - 4	3.6	1.0
Gutierrezia sarothrae	snakeweed	2 - 3	2.5	0.7
Opuntia whipplei	whipple cholla	2 - 3	2.5	0.7
Associated Species				
Lycium andersonii	wolf-berry	4	4.0	0.3
Bromus rubens	red brome	3	3.0	0.3

Physiognomy: Evergreen microphyll desertscrub with scattered half-shrubs and succulents. Height of all shrubs is less than 4 feet (1.2 meters). Estimated total ground cover is 20 to 30 percent.

152.1722

Name: *Atriplex canescens - Yucca baccata - Gutierrezia sarothrae* (Saltbush - Banana Yucca - Snakeweed)

Distribution: Elevational range is 4,000 to 5,200 feet (1,220 to 1,580 meters). This type is found in pockets of level soil in the Esplanade. Soil is sandy loam and is derived from Esplanade Sandstone or from the Wescogame Formation. This type occurs in small pockets, but is widely distributed from the Sanup Plateau to Fossil Bay.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (25)
Atriplex canescens	four-wing saltbush	1 - 4	2.9	0.9
Yucca baccata	banana yucca	2 - 4	2.9	0.9
Gutierrezia sarothrae	snakeweed	1 - 5	3.5	1.0
Perennial Grasses *(Hilaria rigida, Bouteloua gracilis, Oryzopsis hymenoides, Stipa comata)*		2 - 5	3.6	0.8
Ephedra viridis	Mormon tea	2 - 4	2.4	0.8
Associated Species				
Eurotia lanata	winterfat	2 - 4	3.0	0.4
Opuntia phaeacantha	prickly-pear cactus	1 - 4	3.0	0.4
Bromus rubens	red brome	3 - 4	3.5	0.4
Juniperus osteosperma	Utah juniper	1 - 3	2.2	0.4
Coleogyne ramosissima	blackbrush	1 - 3	2.6	0.3
Opuntia echinocarpa	silver cholla	1 - 4	2.7	0.3

Occasional Species: *Artemisia tridentata, Thamnosma montana, Glossopetalon nevadense, Quercus turbinella, Agave utahensis, Opuntia polyacantha, Lycium pallidum, L. andersonii, Chrysothamnus nauseosus, Berberis fremontii, Opuntia erinacea, Eriogonum inflatum.*

Physiognomy: Evergreen microphyll desertscrub with half-shrubs, succulents and perennial grasses. Height of all plants is less than 3 feet (0.9 meters). Estimated total cover is 20 to 30 percent. This type shows considerable variation from site to site because it is included within a variety of different vegetation types, each of which contributes different associated species (Fig. 20).

Figure 20. *Atriplex canescens - Yucca baccata - Gutierrezia sarothrae* (152.1722) on the Esplanade near Flatiron Butte. Pockets of fine textured soil such as this occur widely scattered in restricted localities on the Esplanade.

152.1723

Name: *Atriplex canescens - Eurotia lanata - Ephedra viridis*
(Four-wing Saltbush - Winterfat - Mormon Tea)

Distribution: Elevational range is 5,800 to 6,800 feet (1,770 to 2,070 meters). This type is found on level to rolling terrain of all aspects. Soil is usually shallow with rock fragments and is derived from Kaibab Limestone. This type is found only on top of the plateau in the Cape Solitude area.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (6)
Atriplex canescens	four-wing saltbush	4 - 5	4.5	1.0
Eurotia lanata	winterfat	3 - 4	3.2	0.6
Ephedra viridis	Mormon tea	1 - 4	2.5	0.6
Oryzopsis hymenoides	Indian ricegarss	3 - 4	3.6	0.5
Gutierrezia sarothrae	snakeweed	3 - 4	3.3	0.5
Artemisia nova	black sagebrush	3	3.0	0.5
Associated Species				
Bromus tectorum	cheatgrass	3	3.0	0.3
Artemisia tridentata	big sagebrush	2	2.0	0.3
Opuntia whipplei	Whipple cholla	1 - 2	1.5	0.3

Occasional Species: *Lycium pallidum, Artemisia bigelovii, Chrysothamnus* sp., *Yucca baccata, Juniperus osteosperma, Bouteloua gracilis, Hilaria rigida.*

Physiognomy: Evergreen microphyll desertscrub with half-shrubs and scattered succulents. Height of all plants is less than 3 feet (0.9 meters) and many species are less than 1 foot (0.3 meters). Estimated total cover is 10 to 20 percent.

Warm Desertscrub

Many plants of the inner canyon are sensitive to cold weather and many can be killed by minor freezes. The sensitivity of the warm-desert flora to frost is one of the principal factors limiting its distribution (Turnage and Hinckley, 1938). Warm-desert species characteristic of both the Sonoran and Mohave deserts are common in the canyon, but associations there were classified as Mohave desertscrub due to the predominance of species from that desert. Mohave desertscrub associations are restricted to canyon walls and terraces where freezing temperatures are absent or infrequent, generally below 4,000 feet, but occasionally higher on warm, south-facing slopes. The number of frost-sensitive species increases towards the west in the inner canyon as the frequency and duration of freezing weather decreases.

One seemingly inconsistent feature of the distribution of warm-desert plants in the canyon is the distribution of brittlebush. Brittlebush is one of the most frost-sensitive species, but it extends farther up the canyon than almost any other warm-desert plant. If freezing temperature is the main factor restricting the range of warm-desert species, then many more species should occur at sites where brittlebush can survive.

The vegetation history of the canyon suggests one possible explanation for this pattern. At the end of the last glaciation, woodland species extended to the bottom of the canyon and warm-desert species were absent from the eastern Grand Canyon (Cole, 1981; Phillips, 1977). Warm-desert species which now occur in the eastern canyon, including brittlebush and beavertail cactus, have colonized the area in the last 8,000 to 10,000 years. The species composition of Mohave Desert associations in the eastern canyon may therefore reflect the varying migration rates of different species rather than their ability to withstand the present climate regime of the area.

Although the blackbrush association on the rolling hills and flats of the Tonto Platform is floristically similar to the blackbrush associations of the higher terraces which are classified as Great Basin desertscrub, we consider the Tonto blackbrush to be Mohave desertscrub. The classification decision was based upon the geographical affinities of associated species in these associations. Although the dominants in both areas are the same, on the Tonto the associated species are mostly warm-desert plants such as beavertail cactus, catclaw acacia, rayless encelia and aloysia. The distribution of blackbrush seems to occupy a region of transition between cold-desert and warm-desert communities.

Descriptions of the nineteen warm desertscrub associations used as mapping units at Grand Canyon follow here.

153.1111

Name: *Larrea tridentata - Opuntia basilaris - Fouquieria splendens* (Creosotebush - Beavertail Cactus - Ocotillo)

Distribution: Elevational range is 1,600 to 3,700 feet (490 to 1,130 meters). This type is found on level (slope less than 3 percent) alluvial terraces. Soil is gravelly loam of mixed origin. This type is found above the river downstream from Toroweap Valley.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (3)
Larrea tridentata	creosotebush	5	5.0	1.0
Opuntia basilaris	beavertail cactus	2 - 3	2.5	0.7
Fouquieria splendens	ocotillo	2 - 3	2.5	0.7
Encelia farinosa	brittlebush		2.0	0.7
Ferocactus acanthodes	barrel cactus	1 - 3	2.0	0.7
Associated Species				
Ephedra nevadensis	Mormon tea	4	4.0	0.3
Opuntia acanthocarpa	buckhorn cholla	4	4.0	0.3
Agave utahensis	Utah agave	3	3.0	0.3
Gutierrezia sarothrae	snakeweed	3	3.0	0.3
Ambrosia dumosa	white bursage	2	2.0	0.3
Krameria grayi	white ratany	2	2.0	0.3
Acacia greggii	catclaw acacia	2	2.0	0.3
Echinocereus engelmannii	hedgehog cactus	2	2.0	0.3
Dalea fremontia	indigo bush	1	1.0	0.3

Physiognomy: Evergreen xeromorphic desertscrub with succulents and deciduous shrubs. Height of all species is less than 4 feet (1.2 meters) except *Fouquieria*, which may reach 10 to 12 feet (3.0 to 3.6 meters). Estimated total cover is 10 to 15 percent and spacing of plants is uniform.

153.1121

Name: *Larrea tridentata - Ambrosia dumosa - Ephedra nevadensis* (Creosotebush - White Bursage - Mormon Tea)

Distribution: Elevational range is 3,800 to 5,000 feet (1,160 to 1,520 meters). This type is found on gentle to moderate slopes (5 to 40 percent), generally with southerly aspects. Soil is shallow and gravelly with numerous rock fragments and may be derived from limestone, sandstone or metamorphic rock. This type occurs from Whitmore Wash to Lake Mead.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (20)
Larrea tridentata	creosotebush	3 - 5	4.3	1.0
Ambrosia dumosa	white bursage	1 - 5	4.0	1.0
Ephedra nevadensis	Mormon tea	1 - 3	2.5	0.8
Opuntia basilaris	beavertail cactus	2 - 4	2.7	0.7
Fouquieria splendens	ocotillo	1 - 4	2.4	0.7
Krameria grayi	white ratany	1 - 4	2.4	0.7
Eriogonum inflatum	desert trumpet	2 - 3	2.3	0.7
Ferocactus acanthodes	barrel cactus	1 - 3	2.4	0.6
Associated Species				
Encelia farinosa	brittlebush	2 - 4	3.2	0.5
Echinocereus engelmannii	hedgehog cactus	1 - 2	1.5	0.6
Opuntia acanthocarpa	buckhorn cholla	1 - 4	2.4	0.5
Erioneuron pulchellum	desert fluffgrass	2 - 3	2.6	0.4
Echinocactus polycephalus	manyhead cactus	1 - 2	1.4	0.4
Bromus rubens	red brome	3 - 4	3.2	0.3
Dalea fremontii	indigo bush	1 - 3	2.3	0.3
Lycium andersonii	wolfberry	1 - 2	1.8	0.3
Acacia greggii	catclaw acacia	1 - 2	1.4	0.3
Sphaeralcea ambigua	desert mallow	2 - 4	3.0	0.2
Porophyllum gracile	slender pore-leaf	1 - 2	1.5	0.2

Occasional Species: *Yucca shidigera, Yucca whipplei, Hilaria rigida, Enceliopsis argophylla, Mammillaria microcarpa, Allionia incarnata, Neolloydia johnsoni*

Physiognomy: Evergreen xeromorphic desertscrub with succulents and deciduous shrubs. Height of all species is less than 4 feet (1.2 meters) exept *Fouquieria* which may reach 10 to 12 feet (3.0 to 3.6 meters). Estimated total cover ranges from 10 to 20 percent. This type is the richest in cactus species of any type in the Park.

153.1211

Name: *Coleogyne ramosissima - Ephedra nevadensis/viridis - Yucca baccata* (Blackbrush - Mormon Tea - Banana Yucca)

Distribution: Elevation range is 2,800 to 5,200 feet (850 to 1,580 meters). This type occurs on the level to rolling terrain of the Tonto Platform and Sanup Plateau (slopes up to 40 percent). Soil is moderately deep sandy loam derived from Tapeats Sandstone and Bright Angel Shale. This type is found throughout the inner canyon from Marble Canyon to the Grand Wash Cliffs.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (94)
Coleogyne ramosissima	blackbrush	3 - 5	4.6	1.0
Ephedra nevadensis/ viridis	Mormon Tea	2 - 4	2.7	0.9
Yucca baccata	banana yucca	1 - 4	2.5	0.6
Gutierrezia sarothrae	snakeweed	1 - 5	2.7	0.6
Agave utahensis	Utah agave	1 - 3	2.0	0.6
Encelia frutescens	rayless encelia	1 - 4	1.9	0.5
Acacia greggii	catclaw acacia	1 - 5	1.7	0.5
Associated Species				
Bromus rubens	red brome	1 - 4	2.7	0.5
Opuntia erinacea	grizzly-bear cactus	1 - 4	2.3	0.4
Echinocereus engelmannii	hedgehog cactus	1 - 3	1.5	0.4
Opuntia phaeacantha	prickly-pear cactus	1 - 3	2.2	0.3
Chrysothamnus nauseosus	rabbitbrush	1 - 4	2.1	0.3
Lycium andersonii	wolf-berry	1 - 3	2.0	0.3
Atriplex canescens	four-wing saltbush	1 - 3	2.2	0.2
Thamnosma montana	turpentine broom	1 - 3	1.9	0.2
Sphaeralcea ambigua	desert mallow	1 - 4	1.7	0.2
Opuntia basilaris	beavertail cactus	1 - 3	1.7	0.2

Occasional Species: *Aloysia wrightii, Cowania mexicana, Hilaria rigida, Ephedra torreyana, Parthenium incanum, Juniperus osteosperma, Pinus edulis, Calochartus flexuosus, Encelia farinosa, Rhus trilobata, Stanleya pinnata, Ferocactus acanthodes, Haplopappus spinulosus, Eriogonum inflatum*

Physiognomy: Evergreen microphyll desertscrub with succulents, half-shrubs and scattered deciduous shrubs. Height of all species is less than 3 feet (0.9 meters) except *Acacia*, which may reach 6 feet (1.8 meters). Estimated total cover is 15 to 30 percent (Fig. 21).

Figure 21. *Coleogyne ramosissima* - *Ephedra* spp. - *Yucca baccata* (153.1211) on the Tonto Platform between Boulder and Lonetree Canyons. Although the dominants here are the same as in *Coleogyne* type 152.1311, the associated species here are all warm-desert plants.

153.1212

Name: *Coleogyne ramosissima - Yucca brevifolia - Yucca baccata* (Blackbrush - Joshua-tree - Banana Yucca)

Distribution: Elevational range is 4,500 to 5,100 feet (1,370 to 1,550 meters). This type is found on level and rolling terrain (slopes up to 30 percent) of all aspects. Soil is shallow and rocky and derived from limestone. This type is found only on top of the Grand Wash Cliffs in the extreme southwestern part of the Park.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (8)
Coleogyne ramosissima	blackbrush	4 - 5	4.8	1.0
Yucca brevifolia	joshua-tree	2 - 4	3.1	1.0
Yucca baccata	banana yucca	3 - 4	3.2	0.8
Ephedra viridis	Mormon tea	1 - 3	1.7	0.8
Opuntia acanthocarpa	buckhorn cholla	2 - 3	2.6	0.7
Gutierrezia sarothrae	snakeweed	2 - 3	2.5	0.7
Cowania mexicana	cliffrose	3 - 4	3.4	0.6
Bromus rubens	red brome	2 - 3	2.4	0.8
Associated Species				
Agave utahensis	Utah agave	2 - 4	3.0	0.5
Fallugia paradoxa	Apache plume	1 - 4	2.0	0.5
Opuntia phaeacantha	prickly-pear cactus	1 - 2	1.7	0.5
Atriplex canescens	four-wing saltbush	1 - 2	1.7	0.5
Sphaeralcea ambigua	desert mallow	1 - 2	1.2	0.5
Eriogonum heermannii	Heermann buckwheat	1 - 2	1.6	0.4
Opuntia basilaris	beavertail cactus	1 - 2	1.3	0.4
Poa sp.	———	2 - 3	2.5	0.2
Eriogonum inflatum	desert trumpet	2	2.0	0.2

Occasional Species: *Glossopetalon nevadensis, Artemisia ludoviciana, Opuntia whipplei, Bouteloua eriopoda, Lycium pallidum, Stephanomeria* sp., *Hilaria rigida, Trixis californica, Eriogonum wrightii, Cercocarpus intricatus.*

Physiognomy: Evergreen microphyll desertscrub with arborescent leaf-succulents and scattered half-shrubs and succulents. Height of all plants is less than 3 feet (0.9 meters) except *Yucca brevifolia* which may reach 15 feet (4.5 meters). Estimated total ground cover is 20 to 30 percent. This type includes small swales with fine-texture soils in which *Yucca brevifolia* is occurs as an overstory with a grass-shrub understory similar to 143.1131.

153.1213

Name: *Coleogyne ramosissima - Yucca baccata - Cowania mexicana* (Blackbrush - Banana Yucca - Cliff-rose)

Distribution: Elevational range is 4,500 to 5,500 feet (1,370 to 1,680 meters). This type is found on level to rolling terrain (slopes up to 20 percent) of all aspects. Soil is gravelly with cobbles and is derived from Redwall Limestone. This type occurs only on top of the Grand Wash Cliffs in the extreme southwestern part of the park.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (10)
Coleogyne ramosissima	blackbrush	4 - 5	4.9	1.0
Yucca baccata	banana yucca	3 - 4	3.4	1.0
Cowania mexicana	cliffrose	2 - 4	2.5	0.9
Ephedra viridis	Mormon tea	2 - 3	2.2	0.9
Agave utahensis	Utah agave	1 - 4	2.7	0.8
Gutierrezia sarothrae	snakeweed	2 - 3	2.5	0.8
Opuntia acanthocarpa	buckhorn cholla	2 - 4	2.4	0.7
Atriplex canescens	four-wing saltbush	1 - 3	2.0	0.7
Bromus rubens	red brome	1 - 3	2.2	0.9
Associated Species				
Opuntia phaeacantha	prickly-pear cactus	1 - 3	2.0	0.5
Opuntia basilaris	beavertail cactus	1 - 2	1.7	0.4
Encelia frutescens	rayless encelia	1 - 3	1.5	0.4
Opuntia whipplei	Whipple cholla	1 - 2	1.2	0.4
Aster sp.	———	1 - 2	1.7	0.4
Parthenium incanum	mariola	1 - 4	2.6	0.3
Erioneuron pulchellum	desert fluffgrass	1 - 2	1.6	0.3
Yucca brevifolia	joshua-tree	1 - 2	1.6	0.3
Bouteloua eriopoda	black grama	1 - 2	1.6	0.3
Neolloydia johnsonii	beehive cactus	1 - 2	1.5	0.2
Fallugia paradoxa	Apache plume	2	2.0	0.2

Occasional Species: *Haplopappus spinulosus, Acacia greggii, Trixis californicus, Hilaria rigida, Artemisia ludoviciana, Eriogonum heermannii, Thamnosma montana, Larrea tridentata, Echinocactus polycephalus, Lycium pallidum, Echinocereus engelmannii.*

Physiognomy: Evergreen microphyll desertscrub with succulents and scattered half-shrubs. Height of all plants is less than 3 feet (0.9 meters) except *Cowania*, which may reach 5 feet (1.5 meters). Estimated total ground cover is 15 to 30 percent.

153.1721

Name: *Atriplex hymeneletra - Larrea tridentata - Ambrosia dumosa* (Desert Holly - Creosotebush - White Bursage)

Distribution: Elevational range is 1,500 to 1,600 feet (460 to 490 meters). This type is found on moderate to steep slopes (15 to 50 percent) of all exposures. Soil is deep gravelly alluvium. This type is found at only one site in the park on the south shore of Lake Mead.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (1)
Atriplex hymeneletra	desert holly	5	—	—
Larrea tridentata	creosotebush	4	—	—
Ambrosia dumosa	white bursage	4	—	—
Tridens pulchellum	desert fluffgrass	3	—	—
Associated Species				
Echinocactus polycephalus	manyhead cactus	2	—	—
Eriogonum inflatum	desert trumpet	2	—	—

Occasional Species: *Echinocereus engelmannii, Lycium andersonii, Opuntia acanthocarpa, Aster abatus, Dalea fremontii, Fouquieria splendens.*

Physiognomy: Evergreen xeromorphic desertscrub with cacti. Height of all species is less than 3 feet (0.9 meters), and most are less than 2 feet (0.6 meters). Estimated total cover is 5 to 15 percent.

153.1731

Name: *Atriplex canescens - Opuntia erinacea - Prosopis glandulosa* (Four-wing Saltbush - Grizzly-bear Cactus - Mesquite)

Distribution: Elevational range is 2,300 to 2,800 feet (700 to 850 meters). This type is found on level (slopes less than 2 percent) alluvial terraces near river level. Soil is silty loam. This type occurs only in the eastern part of the park between Tanner Canyon and Cardenas Creek on the south side of the river.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (2)
Atriplex canescens	four-wing saltbush	4 - 5	4.5	1.0
Opuntia erinacea	grizzly-bear cactus	3 - 4	3.5	1.0
Prosopis glandulosa	mesquite	1	1.0	1.0
Associated Species				
Suaeda torreyana	seep weed	2	2.0	0.5
Opuntia basilaris	beavertail cactus	1	1.0	0.5
Ephemeral Species				
Calycoseris parryi	yellow tack-stem	4	4.0	1.0
Chaenactis steveoides	Esteve pincushion	3 - 4	3.5	1.0
Erodium texanum	storksbill	2	2.0	0.5
Bromus rubens	red brome	2	2.0	0.5

Physiognomy: Evergreen microphyll desertscrub with cacti and occasional deciduous shrubs. Ephemeral species may be abundant in the rainy season. Estimated total cover is 5 to 10 percent. Mesquite is sparse away from the river, but along the shore it forms thickets which are the closest approximation to mesquite "bosques" found in the park (Fig. 22).

Figure 22. *Atriplex canescens - Opuntia erinacea -Prosopis glandulosa* (153.1731) along the Colorado River near Cardenas Creek. The thicket in the left-rear closely resembles a mesquite bosque, and is the only such area found in the park. Note the sparseness of vegetation in the foreground.

153.1741

Name: *Atriplex confertifolia - Ephedra nevadensis - Opuntia basilaris* (Shadscale - Mormon Tea - Beavertail Cactus)

Distribution: Elevational range is 3 100 to 4,800 feet (950 to 1,460 meters). This type is found on rolling terrain with gentle to moderate slopes (up to 40 percent) of all aspects. Soil is shallow, gravelly and poorly developed. The substrate is unstable and is derived from the friable silt- and mud-stones of the Grand Canyon Series and Hermit Shale. This type occurs only in the eastern part of the park in the Chuar and Kwagunt Valleys and Marble Canyon.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (22)
Atriplex confertifolia	shadscale	2 - 5	3.8	1.0
Ephedra nevadensis/ torreyana	Mormon tea	1 - 4	3.3	0.8
Eriogonum inflatum	desert trumpet	2 - 3	2.6	0.7
Lycium andersonii	wolf-berry	1 - 3	2.3	0.6
Opuntia erinacea	grizzly-bear cactus	1 - 4	2.8	0.5
Opuntia basilaris	beavertail cactus	1 - 4	2.8	0.5
Associated Species				
Acacia greggii	catclaw acacia	2 - 5	2.9	0.4
Gutierrezia sarothrae	snakeweed	1 - 5	2.6	0.5
Bromus rubens	red brome	2 - 3	2.7	0.7
Encelia frutescens	rayless encelia	1 - 3	2.0	0.3
Echinocereus engelmannii	hedgehog cactus	1 - 3	2.3	0.4
Tiquilia latior	———	1 - 3	2.3	0.2
Porophyllum gracile	slender pore-leaf	2	2.0	0.2
Echinocactus polycephalus	manyhead cactus	1 - 3	1.8	0.2

Occasional Species: *Bebbia juncea, Dyssodia* sp., *Aster abatus, Stephanomeria* sp., *Atriplex canescens, Thamnosma montana, Dalea fremontii, Prosopis glandulosa, Encelia farinosa.*

Physiognomy: Evergreen xeromorphic desertscrub with cacti and deciduous shrubs. Height of all species is less than 2 feet (0.6 meters), except *Acacia* which may reach 4 feet (1.2 meters). Estimated total cover is 5 to 20 percent. In some places the substrate is so unstable and surface movement so great, that establishment of young perennial species is almost absent.

153.1811

Name: *Sphaeralcea ambigua - Ephedra nevadensis - Larrea tridentata* (Desert Mallow - Mormon Tea - Creosotebush)

Distribution: Elevational range is 1,500 to 3,200 feet (460 to 980 meters). This type is found on moderate to steep slopes (15 to 50 percent) of northerly aspect. The soil is shallow and cobbly and may be derived from limestone or metamorphic rock. This type occurs in the inner gorge downstream from Whitmore Wash to Lake Mead.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (10)
Sphaeralcea ambigua	desert mallow	4 - 5	4.5	1.0
Ephedra nevadensis	Mormon tea	2 - 4	2.9	1.0
Larrea tridentata	creosotebush	2 - 4	2.6	0.9
Acacia greggii	catclaw acacia	1 - 3	2.0	0.9
Fouquieria splendens	ocotillo	1 - 4	2.5	0.8
Yucca whipplei	Our-Lord's-candle	2 - 3	2.6	0.8
Ferocactus acanthodes	barrel cactus	1 - 3	2.1	0.8
Associated Species				
Encelia farinosa	brittlebush	1 - 4	3.0	0.5
Gutierrezia sarothrae	snakeweed	1 - 3	2.0	0.5
Encelia frutescens	rayless encelia	1 - 3	2.2	0.5
Opuntia acanthocarpa	buckhorn cholla	1 - 3	2.5	0.5
Agave utahensis	Utah agave	1 - 4	2.2	0.5
Echinocereus engelmannii	hedgehog cactus	1 - 2	1.4	0.5
Eriogonum inflatum	desert trumpet	1 - 2	1.4	0.5
Mortonia scabrella	sandpaper bush	2 - 4	2.7	0.3
Echinocactus polycephalus	manyhead cactus	2 - 3	2.7	0.3
Thamnosma montana	turpentine broom	1 - 2	1.3	0.3
Galium stellatum	bedstraw	2	2.0	0.3
Cheilanthes sp.	lip fern	1	1.0	0.3
Krameria grayi	white ratany	2	2.0	0.2
Opuntia basilaris	beavertail cactus	2	2.0	0.2
Trixis californica	———	1 - 2	1.5	0.2
Crossosoma bigelovii	ragged rock flower	1 - 2	1.5	0.2

Occasional Species: *Ambrosia dumosa, Bebbia juncea, Hilaria rigida, Opuntia echinocarpa, Stanleya pinnata, Amsonia brevifolia, Eucnide urens, Tiquilia latior.*

Physiognomy: Mixed deciduous and evergreen xeromorphic desertscrub with cacti and half-shrubs. Height of all species is less than 3 feet (0.9 meters), except *Acacia* which may reach 4 feet (1.2 meters) and *Fouquieria* which may reach 10 feet (3 meters). Estimated total cover ranges from 10 to 20 percent (Fig. 23).

Figure 23. *Sphaeralcea ambigua* - *Ephedra nevadensis* - *Larrea tridentata* (153.1811) along the Colorado River near Lake Mead. Grasses are common in this type.

153.1812

Name: *Sphaeralcea ambigua - Dalea fremontii - Fouquieria splendens* (Desert Mallow - Indigo-bush - Ocotillo)

Distribution: Elevational range is 1,500 to 2,000 feet (460 to 610 meters). This type is found on moderate to steep slopes (20 to 50 percent) of all aspects. Soil is coarse, cobbly and usually shallow with frequent bedrock outcrops; it is usually derived from Redwall Limestone. This type occurs at the extreme western end of the park west of the Grand Wash Cliffs.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (17)
Sphaeralcea ambigua	desert mallow	1 - 5	3.8	1.0
Dalea fremontii	indigo-bush	1 - 5	3.4	1.0
Fouquieria splendens	ocotillo	2 - 4	2.4	1.0
Ephedra nevadensis	Mormon tea	1 - 4	2.8	0.9
Opuntia basilaris	beavertail cactus	1 - 3	1.9	0.9
Larrea tridentata	creosotebush	1 - 4	3.2	0.8
Eriogonum inflatum	desert trumpet	1 - 2	1.9	0.7
Associated Species				
Opuntia acanthocarpa	buckhorn cholla	1 - 3	2.1	0.5
Echinocereus engelmannii	hedgehog cactus	1 - 3	2.1	0.5
Yucca whipplei	Our-Lord's-candle	1 - 4	2.2	0.3
Echinocactus polycephalus	manyhead cactus	1 - 2	1.4	0.3
Encelia frutescens	rayless encelia	2 - 4	2.8	0.3
Gutierrezia sarothrae	snakeweed	2 - 3	2.4	0.3
Ferocactus acanthodes	barrel cactus	1 - 2	1.4	0.3
Krameria grayi	white ratany	1 - 2	1.5	0.3
Aster abatus	———	2 - 3	2.5	0.3
Amsonia brevifolia	blue star	2	2.0	0.2
Neolloydia johnsonii	beehive cactus	1 - 2	1.3	0.2
Agave utahensis	Utah agave	2 - 3	2.3	0.2
Acacia greggii	catclaw acacia	2	2.0	0.2
Ambrosia dumosa	white bursage	1 - 2	1.5	0.2

Occasional Species: *Encelia farinosa, Thamnosma montana, Tiquilia latior, Bebbia juncea, Cheilanthes* sp., *Gallium stellatum, Opuntia echinocarpa, Mortonia scabrella, Yucca shidigera.*

Physiognomy: Mixed deciduous and evergreen xeromorphic desertscrub with cacti and half-shrubs. Height of all species is less than 3 feet (0.9 meters) except *Fouquieria* which may reach 10 feet (3 meters). Estimated total cover ranges from 10 to 20 percent and is somewhat patchy. Two species of interest, *Arctomecon californica* and *Yucca whipplei*, are generally restricted to this type in the park.

153.1911

Name: *Encelia farinosa - Larrea tridentata - Ephedra nevadensis* (Brittlebush - Creosotebush - Mormon Tea)

Distribution: Elevational range is 1,500 to 3,500 feet (460 to 1,070 meters). This type is found on moderate to steep slopes (up to 50 percent) with southerly aspects. Soils are thin and rocky or cobbly, derived from the Bright Angel Shale, Tapeats Sandstone, igneous rocks and volcanics. The type occurs on slopes above the river from Toroweap Point to Lake Mead.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (35)
Encelia farinosa	brittlebush	2 - 5	4.4	1.0
Larrea tridentata	creosotebush	2 - 5	3.8	1.0
Ephedra nevadensis	Mormon tea	1 - 5	2.6	0.7
Ferocactus acanthodes	barrel cactus	1 - 3	2.4	0.7
Fouquieria splendens	ocotillo	1 - 4	2.6	0.6
Opuntia basilaris	beavertail cactus	1 - 3	2.0	0.6
Associated Species				
Sphaeralcea ambigua	desert mallow	1 - 4	2.3	0.5
Opuntia acanthocarpa	buckhorn cholla	1 - 3	1.6	0.4
Bromus rubens	red brome	2 - 4	2.6	0.5
Krameria grayi	white ratany	1 - 3	1.9	0.3
Acacia greggii	catclaw acacia	1 - 3	1.7	0.3
Yucca whipplei	Our-Lord's-candle	1 - 2	1.7	0.3
Echinocactus polycephalus	manyhead cactus	1 - 3	1.6	0.3
Echinocereus engelmannii	hedgehog cactus	1 - 2	1.4	0.3
Eriogonum inflatum	desert trumpet	2 - 3	2.8	0.2
Erioneuron pulchellum	desert fluffgrass	1 - 2	1.7	0.2

Occasional Species: *Peucephyllum schottii, Dalea fremontii, Porophyllum gracile, Lycium andersonii, Encelia frutescens, Trixis californica, Eucnide urens, Agave utahensis, Gutierrezia sarothrae, Bebbia juncea, Salazaria mexicana.*

Physiognomy: Mixed evergreen and deciduous xeromorphic desertscrub with subshrubs and cacti scattered throughout. Annual grasses and herbs are seasonal, often fairly dense. The plants are 1 to 3 feet (0.3 to 0.9 meters) tall except *Fouquieria* which may reach 8 to 10 feet (2.4 to 3.0 meters) tall. Estimated total cover ranges from 5 to 20 percent. Plant distribution tends to be patchy and uneven because the substrate is frequently interrupted by barren bedrock outcrops and talus slopes. Two species of restricted distribution in the park, *Peucephyllum schottii* and *Eucnide urens*, are found on scattered rock faces in this type (Fig. 24).

Figure 24. *Encelia farinosa - Larrea tridentata - Ephedra nevadensis* (153.1911) at Whitmore Wash. This type contains many of the most frost-sensitive species in the park.

153.1912

Name: *Encelia farinosa - Ephedra nevadensis/viridis - Acacia greggii* (Brittlebush - Mormon Tea - Catclaw Acacia)

Distribution: Elevational range is 2,000 to 4,400 feet (610 to 1,340 meters). This type is found on moderate to steep slopes, predominantly on southerly aspects. The soil is rocky and shallow with frequent bedrock outcrops, derived from igneous rocks. Tapeats Sandstone, Muav Limestone and Bright Angel Shale. The type is found throughout the inner gorge from lower Marble Canyon downstream almost to Toroweap Point.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (65)
Encelia farinosa	brittlebush	1 - 5	3.6	1.0
Ephedra nevadensis/ viridis	Mormon tea	1 - 5	3.6	0.9
Acacia greggii	catclaw acacia	1 - 4	2.2	0.8
Opuntia basilaris	beavertail cactus	1 - 4	2.5	0.5
Associated Species				
Echniocereus engelmannii	hedgehog cactus	1 - 2	1.6	0.4
Bromus rubens	red brome	1 - 4	2.6	0.7
Gutierrezia sarothrae	snakeweed	2 - 5	3.2	0.3
Lycium andersonii	wolf-berry	1 - 4	2.7	0.3
Galium stellatum	bed-straw	1 - 4	2.1	0.3
Agave utahensis	Utah agave	1 - 3	2.1	0.3
Haplopappus spinulosus	———	1 - 4	1.9	0.3
Eriogonum inflatum	desert trumpet	1 - 5	1.8	0.3
Atriplex canescens	four-wing saltbush	1 - 4	2.7	0.2
Opuntia erinacea	grizzly-bear cactus	1 - 4	2.6	0.2
Opuntia phaeacantha	prickly-pear cactus	1 - 3	2.4	0.2
Sphaeralcea ambigua	desert mallow	1 - 4	2.2	0.2
Ferocactus acanthodes	barrel cactus	1 - 3	2.3	0.2
Bebbia juncea	sweet-bush	1 - 4	1.9	0.2
Porophyllum gracile	slender pore-leaf	1 - 3	1.8	0.2
Echinocactus polycephalus	manyhead cactus	1 - 2	1.3	0.2

Occasional Species: *Dyssodia pentachaeta, Encelia frutescens, Thamnosma montana, Hilaria rigida, Aloysia wrightii, Tiquilia latior, Aster abatus, Yucca angustissima, Dalea fremontii, Trixis californicus.*

Physiognomy: Xeromorphic desertscrub with cacti scattered throughout the type. All species are 1 to 3 feet (0.3 to 0.9 meters) tall. Estimated total cover ranges from 5 to 20 percent, but patchy due to barren rock faces and talus slopes.

153.11011

Name: *Gutierrezia sarothrae - Ephedra viridis - Agave utahensis* (Snakeweed - Mormon Tea - Utah agave)

Distribution: Elevational range is 2,400 to 5,000 feet (730 to 1,520 meters). This type is found on steep unstable talus slopes of all aspects. Soils are coarse with many cobbles and boulders, derived from Redwall Limestone or geological formations of lower elevation. The type is found in the inner canyon from Marble Canyon to the Shivwits Plateau.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (80)
Gutierrezia sarothrae	snakeweed	2 - 5	3.8	0.9
Ephedra viridis	Mormon tea	1 - 5	3.3	0.8
Agave utahensis	Utah agave	1 - 4	2.0	0.6
Accia greggii	catclaw acacia	1 - 4	2.4	0.5
Encelia frutescens	rayless encelia	1 - 4	2.3	0.5
Sphaeralcea ambigua	desert mallow	1 - 4	2.3	0.5
Associated Species				
Bromus rubens	red brome	1 - 4	2.8	0.6
Artemisia ludoviciana	———	1 - 4	2.7	0.4
Rhus trilobata	skunkbush	1 - 4	2.2	0.4
Echinocereus engelmannii	hedgehog cactus	1 - 3	1.9	0.4
Opuntia erinacea	grizzly-bear cactus	1 - 4	2.7	0.3
Atriplex canescens	four-wing saltbush	1 - 4	2.7	0.3
Chrysothamnus nauseosus	rabbitbrush	1 - 4	2.6	0.3
Yucca baccata	banana yucca	1 - 4	2.5	0.3
Coleogyne ramosissima	blackbrush	1 - 4	2.3	0.3
Eriogonum inflatum	desert trumpet	1 - 4	2.2	0.3
Opuntia phaeacantha	prickly-pear cactus	1 - 3	2.0	0.3
Aloysia wrightii	oreganillo	1 - 4	2.0	0.3
Brickellia atractyloides	———	1 - 3	1.7	0.3
Ephedra torreyana	Mormon tea	2 - 4	3.1	0.2
Haplopappus spinulosus	———	1 - 4	2.6	0.2
Bernardia incana	———	1 - 4	2.5	0.2
Thamnosma montana	turpentine broom	1 - 3	1.9	0.2

Occasional Species: *Parthenium incanum, Lycium andersonii, Tiquilia latior, Dyssodia pentachaeta, Opuntia basilaris, Aster abatus, Echinocactus polycephalus, Galium stellatum, Juniperus osteosperma, Acourtia wrightii, Ptelea trifoliata, Yucca angustissima, Cowania mexicana, Artemisia nova, Hilaria rigida, Amsonia* sp.

Physiognomy: Mixed evergreen and deciduous xeromorphic desertscrub with succulents and cacti scattered throughout the type. Annual grasses and herbs are common. All plants are 1 to 3 feet (0.3 to 0.9 meters) tall, except *Acacia greggii* which occasionally reaches 4 to 5 feet (1.2 to 1.5 meters) tall. Estimated total cover ranges from 10 percent on exposed sites to 40 percent in the most protected situations. This is one of the most widespread and variable types in the park. The two principal factors influencing species composition appear to be slope exposure and slope stability. Different slopes have varying histories of disturbance due to down-slope movement caused by rockfalls. Variation within this type is related to a mosaic of talus slopes with different disturbance histories occupied by species with different colonization rates (Fig. 25).

Figure 25. *Gutierrezia sarothrae - Ephedra viridis - Agave utahensis* (153.11011) in Lonetree Canyon above the Tonto Platform. Pictured is a steep canyon slope which is subject to periodic disturbance by rock falls, creating a complex mosaic of patches with different disturbance histories on the hillside.

153.11012

Name: *Ephedra nevadensis/viridis - Salvia carnosa - Lycium andersonii* (Mormon Tea - Desert Sage - Wolf-berry)

Distribution: Elevational range is 2,800 to 3,900 feet (850 to 1,190 meters). This type is restricted to steep scree slopes with northerly exposures. Soils are loose gravelly scree derived from Unkar Group shales, sandstones and quartzites. It has been observed at only a few scattered localities in the 75-mile Canyon-Cardenas Creek area and at Thunder River. The type is characterized by very unstable substrate.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (8)
Ephedra nevadensis/ viridis	Mormon tea	3 - 4	3.8	1.0
Salvia carnosa	desert sage	3 - 5	3.5	1.0
Lycium andersonii	wolf-berry	3 - 4	3.7	0.8
Gutierrezia sarothrae	snakeweed	1 - 3	2.2	0.6
Thamnosma montana	turpentine broom	1 - 3	1.8	0.6
Associated Species				
Opuntia erinacea	grizzly-bear cactus	2 - 3	2.8	0.5
Encelia frutescens	rayless encelia	2 - 3	2.5	0.5
Acacia greggii	catclaw acacia	2 - 3	2.3	0.4
Astragalus sp.	loco weed	2	2.0	0.4
Brickellia atractyloides	———	1 - 2	1.7	0.4
Opuntia basilaris	beavertail cactus	3	3.0	0.3
Bromus rubens	red brome	2 - 3	2.5	0.4
Cryptantha sp.	———	2	2.0	0 4
Aloysia wrightii	oreganillo	2 - 3	2.5	0.3
Yucca angustissima	datil	2	2.0	0.3
Agave utahensis	Utah agave	1 - 2	1.5	0.3

Occasional Species: *Echinocactus polycephalus, Echinocereus engelmannii, Atriplex canescens, Cryptantha capitata, Opuntia phaeacantha, Rhus trilobata, Chrysothamnus nauseosus.*

Physiognomy: Xeromorphic desertscrub with cacti scattered throughout. All plants are 1 to 2 (0.3 to 0.6 meters) tall. Estimated total cover is low, usually 5 to 15 percent.

153.11013

Name: *Ambrosia dumosa - Ephedra nevadensis - Ferocactus acanthodes* (White Bursage - Mormon Tea - Barrel Cactus)

Distribution: Elevational range is 2,000 to 3,900 feet (610 to 1,190 meters). This type is found on moderate to steep slopes of southerly aspects. Soils are thin, coarse, and rocky derived from limestone, shale and landslide debris. This type occurs in the inner gorge in the Tapeats Creek - Deer Creek area.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (14)
Ambrosia dumosa	white bursage	2 - 4	3.4	1.0
Ephedra nevadensis	Mormon tea	2 - 4	3.4	1.0
Ferocactus acanthodes	barrel cactus	2 - 4	2.9	1.0
Gutierrezia sarothrae	snakeweed	2 - 4	3.2	0.7
Opuntia phaeacantha	prickly-pear cactus	2 - 4	2.6	0.6
Agave utahensis	Utah agave	1 - 3	2.5	0.6
Hilaria rigida	big galleta	2 - 3	2.4	0.6
Acacia greggii	catclaw acacia	1 - 3	2.1	0.6
Sphaeralcea ambigua	desert mallow	1 - 3	2.0	0.6
Associated Species				
Encelia farinosa	brittlebush	2 - 5	3.6	0.5
Haplopappus spinulosus	———	1 - 3	2.4	0.5
Bromus rubens	red brome	2 - 4	3.1	0.7
Lycium andersonii	wolf-berry	1 - 2	1.3	0.3
Porophyllum gracile	slender pore-leaf	2	2.0	0.3
Eurotia lanata	winterfat	3	3.0	0.2
Galium stellatum	bed-straw	1 - 3	1.5	0.2
Echinocereus engelmannii	hedgehog cactus	1 - 2	1.5	0.2
Aloysia wrightii	oreganillo	1 - 2	1.3	0.2

Occasional Species: *Eriogonum inflatum, Dyssodia pentachaeta, Thamnosma montana, Peucephyllum schottii, Aster abatus, Opuntia basilaris, Acourtia wrightii, Allionia incarnata, Encelia frutescens.*

Physiognomy: Evergreen microphyll desertscrub with deciduous shrubs and cacti scattered throughout. Annual grasses and herbs are common. All plants are from 1 to 3 feet (0.3 to 0.9 meters) tall. Estimated total cover ranges from 10 to 20 percent.

153.11014

Name: *Ephedra viridis/torreyana - Gutierrezia sarothrae - Lycium andersonii* (Mormon Tea - Snakeweed - Wolf-berry)

Distribution: Elevational range is 2,400 to 6,100 feet (730 to 1,860 meters). This type is found on moderate to steep slopes of all aspects occasionally occurring on higher elevations of southerly aspects. Soils are thin and coarse with gravel and cobbles on limestones, sandstones and shales. The type is found in Marble Canyon and in the eastern Grand Canyon from Nankoweap Creek to Red Canyon.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (79)
Ephedra viridis/ torreyana	Mormon tea	1 - 5	3.7	1.0
Gutierrezia sarothrae	snakeweed	2 - 4	3.4	0.6
Lycium andersonii	wolf-berry	1 - 5	3.2	0.6
Acacia greggii	catclaw acacia	1 - 4	2.4	0.6
Eriogonum inflatum	desert trumpet	1 - 4	2.1	0.6
Bromus rubens	red brome	1 - 4	2.8	0.8
Associated Species				
Opuntia basilaris	beavertail cactus	1 - 4	2.6	0.5
Atriplex canescens	four-wing saltbush	1 - 4	2.9	0.4
Opuntia erinacea	grizzly-bear cactus	1 - 3	2.4	0.4
Encelia frutescens	rayless encelia	1 - 4	2.3	0.3
Agave utahensis	Utah agave	1 - 4	2.1	0.3
Echinocereus engelmannii	hedgehog cactus	1 - 3	2.0	0.3
Sphaeralcea ambigua	desert mallow	1 - 3	2.0	0.3
Echinocactus polycephalus	manyhead cactus	1 - 3	1.9	0.3
Haplopappus spinulosus	———	1 - 4	2.7	0.2
Hilaria rigida	big galleta	1 - 4	2.5	0.2
Galium stellatum	bed-straw	1 - 4	2.1	0.2
Tiquilia latior	———	1 - 3	2.0	0.2
Thamnosma montana	turpentine broom	1 - 3	1.5	0.2

Occasional Species: *Encelia farinosa, Artemisia ludoviciana, Yucca angustissima, Chrysothamnus nauseosus, Aloysia wrightii, Stanleya pinnata, Brickellia atractyloides, Yucca baccata.*

Physiognomy: Microphyll desertscrub with cacti and annual grasses and herbs scattered throughout. Shrubs are 1 to 2 feet (0.3 to 0.6 meters) except for *Acacia greggii* which may reach 4 feet (1.2 meters). Estimated total cover is 5 to 20 percent, variable and patchy depending upon slope stability.

153.11015

Name: *Lycium andersonii - Gutierrezia sarothrae - Atriplex confertifolia* (Wolf-berry - Snakeweed - Shadscale)

Distribution: Elevational range is 4,200 to 5,100 feet (1,280 to 1,550 meters). This type is found on moderate to steep slopes with southerly aspects. Soils are thin and gravelly with numerous cobbles derived from basalt flows. This type is limited to Vulcan's Throne.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (5)
Lycium andersonii	wolf-berry	3 - 4	3.6	1.0
Gutierrezia sarothrae	snakeweed	3 - 5	4.0	0.8
Atriplex confertifolia	shadscale	3	3.0	0.8
Ephedra viridis	Mormon tea	3	3.0	0.8
Yucca baccata	banana yucca	2 - 3	2.8	0.8
Associated Species				
Salazaria mexicana	bladder-sage	4	4.0	0.4
Artemisia tridentata	big sagebrush	4	4.0	0.2
Thamnosma montana	turpentine broom	3	3.0	0.2
Fendlera rupicola	fendlerbush	3	3.0	0.2
Opuntia erinacea	grizzly-bear cactus	2	2.0	0.2
Larrea tridentata	creosotebush	1	1.0	0.2

Physiognomy: Xeromorphic evergreen desertscrub with cacti scattered throughout the type. All plants are 1 to 2 feet (0.3 to 0.6 meters) tall. Estimated total cover ranges from 15 to 40 percent and is evenly distributed.

153.11016

Name: *Ephedra viridis - Hilaria rigida - Acacia greggii* (Mormon Tea - Big Galleta - Catclaw Acacia)

Distribution: Elevational range is 1,900 to 3,200 feet (580 to 980 meters). This type is found on moderate to steep slopes of northern aspects. Soils are thin, coarse and rocky derived from limestone, sandstone, igneous rocks and slump material. The type is located in the inner canyon from Elves Chasm downstream to Havasu Creek.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (15)
Ephedra viridis	Mormon tea	3 - 5	4.1	1.0
Hilaria rigida	big galleta	2 - 4	3.3	1.0
Acacia greggii	catclaw acacia	1 - 4	2.0	0.9
Gutierrezia sarothrae	snakeweed	2 - 4	3.4	0.8
Haplopappus spinulosus	———	1 - 3	2.3	0.8
Sphaeralcea ambigua	desert mallow	1 - 4	2.8	0 7
Ferocactus acanthodes	barrel cactus	1 - 3	2.5	0.6
Associated Species				
Echinocereus engelmannii	hedgehog cactus	2 - 3	2.3	0.5
Agave utahensis	Utah agave	2 - 4	2.3	0.5
Galium stellatum	bed-straw	1 - 3	2.0	0.5
Porophyllum gracile	slender pore-leaf	1 - 2	1.8	0.5
Encelia farinosa	brittlebush	1 - 3	1.6	0.5
Lycium andersonii	wolf-berry	2 - 4	2.8	0.4
Opuntia phaeacantha	prickly-pear cactus	1 - 4	2.2	0.4
Amsonia sp.	blue-star	2 - 4	2.5	0.3
Opuntia erinacea	grizzly-bear cactus	2 - 3	2.7	0.2
Eurotia lanata	winterfat	2 - 3	2.7	0.2
Aster abatus	———	1 - 3	2.0	0.2

Occasional Species: *Opuntia basilaris, Eriogonum inflatum, Echinocactus polycephalus, Acourtia wrightii, Nolina microcarpa, Peucephyllum schottii, Encelia frutescens.*

Physiognomy: Mixed evergreen and deciduous xeromorphic desertscrub with perennial grass, scattered cacti and annual grasses. Shrubs are 1 to 3 feet (0.3 to 0.9 meters) tall and grass is usually 1 foot (0.3 meters) or less. Estimated total cover is 15 to 25 percent. This type occupies the most mesic slopes of the Inner Gorge and commonly has higher ground cover than other desertscrub types in the canyon.

153.11017

Name: *Ephedra nevadensis - Coleogyne ramosissima - Larrea tridentata* (Mormon Tea - Blackbrush - Creosotebush)

Distribution: Elevational range is 3,600 to 4,100 feet (1,100 to 1,250 meters). The type is found on gentle to moderate slopes generally on southerly aspects. Soils are thin, coarse and rocky derived primarily from limestones. This type occurs in the inner canyon below the Shivwits Plateau.

Floristics:

Characteristic Species		Prominence Range	Prominence Mean	Frequency (8)
Ephedra nevadensis	Mormon tea	2 - 4	3.0	1.0
Coleogyne ramosissima	blackbrush	1 - 5	3.0	0.9
Larrea tridentata	creosotebush	3 - 4	3.3	0.8
Yucca baccata	banana yucca	1 - 3	2.8	1.0
Opuntia echinocarpa	silver cholla	1 - 3	2.0	1.0
Ferocactus acanthodes	barrel cactus	2 - 3	2.6	0.9
Fouquieria splendens	ocotillo	2 - 4	2.8	0.8
Aloysia wrightii	oreganillo	2 - 3	2.5	0.8
Thamnosma montana	turpentine broom	2 - 3	2.2	0.8
Acacia greggii	catclaw acacia	1 - 3	2.0	0.8
Aster abatus	———	1 - 3	1.7	0.8
Associated Species				
Agave utahensis	Utah agave	2 - 3	2.8	0.6
Encelia frutescens	rayless encelia	2 - 4	2.6	0.6
Tiquilia latior	———	1 - 3	2.0	0.6
Sphaeralcea ambigua	desert mallow	1 - 4	3.0	0.5
Eriogonum wrightii	buckwheat	2 - 4	3.0	0.5
Gutierrezia sarothrae	snakeweed	1 - 3	2.3	0.5
Muhlenbergia sp.	muhly	2 - 3	2.5	0.5
Canotia holocantha	crucifixion thorn	1 - 3	2.0	0.5
Opuntia erinacea	grizzly-bear cactus	1 - 2	1.5	0.5
Echinocereus engelmannii	hedgehog cactus	1 - 2	1.5	0.5
Parthenium incanum	mariola	2 - 4	1.5	0.5
Eriogonum inflatum	desert trumpet	2 - 3	2.3	0.4
Bromus rubens	red brome	2 - 3	2.7	0.4
Opuntia basilaris	beavertail cactus	1 - 3	1.7	0.4
Dyssodia pentachaeta	dogweed	1 - 2	1.7	0.4

Occasional Species: *Hilaria rigida, Oryzopsis hymenoides, Haplopappus spinulosus, Acourtia wrightii, Opuntia phaeacantha, Mortonia scabrella.*

Physiognomy: Evergreen microphyll desertscrub with deciduous shrubs and cacti scattered throughout. Shrubs and cacti are 1 to 3 feet (0.3 to 0.9 meters) tall except *Fouquieria* and *Acacia* which may reach 4 to 8 feet (1.2 to 2.4 meters) tall. Estimated total cover ranges from 15 to 25 percent.

Riparian Woodland and Scrub

Riparian vegetation is the most complex and variable assemblage of plants in the park. Each dry wash, spring, seep, pond, or stream has a different association of species, depending upon salient environmental features. These features may include elevation, grade, permanence of water, substrate, the frequency of scouring floods, and differential immigration rates among the array of possible riparian colonizers. The fact that vegetation along drainages is highly susceptible to disturbance by seasonal flooding is apparently an important factor determining species composition of riparian plant communities.

A general change in riparian species can be noted from the east end of the Grand Canyon to the west end, reflecting an increase in frost-sensitive species. However, these species differences are subtle and were not significant enough to warrant classification as separate types at our mapping scale.

For purposes of the vegetation map, all riparian vegetation was divided into two classes. One type consisted of vegetation associated with perennial water such as springs and streams in side canyons having a gallery of tall trees such as cottonwood or ash, with a variable lower synusia (223.2121). Vegetation associated with water courses having only intermittent or ephemeral flow and lacking the woodland gallery element was combined to form the second type (253.4221). This simple dichotomy of riparian vegetation is artificial to some extent because the amount and duration of water flow varies from stream to stream and creates a broad continuum of possible species assemblages.

The areas occupied by riparian vegetation are extremely variable, but generally occur as small, discrete linear strands along drainages or as small patches at springs or standing water sources. Tiny wetland units of riparian vegetation may occur at any elevation or in any location in the park where standing water or seeps are present. Often these areas are too small to appear on the maps. An example would be the numerous "sinkhole" ponds which occur on the North Rim as a result of karst topography. These retain water much of the year and many support higher elevation wetland vegetation in units that are normally too small to map. Mappable riparian areas usually begin at or below the Redwall Limestone, where slopes are less steep, and extend down to the Colorado River. Riparian vegetation may abruptly end at steep rock faces where rock types change, such as where a drainage drops over the ledges of the Tapeats Sandstone into the Inner Granite Gorge.

Species which are normally non-riparian at higher elevations may be found at lower elevations in riparian or semi-riparian situations. For example, Gambel's oak is an upland species associated with ponderosa pine forests, deciduous scrub, or more mesic pinyon-juniper woodlands at higher elevations. However, it is found in riparian situations along intermittent and ephemeral drainages within the lower elevation, more xeric pinyon-juniper wooldlands on the Kanab Plateau. The extra water, cold air drainage, and lower evaporation rates provided by these watercourses apparently allow their occurrence at lower elevations. Conversely, riparian communities along intermittent and ephemeral drainages are often dominated by species that are elements of the drier upland vegetation immediately adjacent to them.

The riparian woodland vegetation occurring in association with the emergence of large spring systems from the Muav and Redwall Limestone exhibits the largest percentage of rare, localized, and obligate riparian species within the park. The

riparian vegetation at Roaring Springs, Vasey's Paradise, Deer Creek, Thunder River, and Clear Creek Springs are examples of these unique and important types. The nearest known location in the region of habitats supporting similar vegetation is at Oak Creek Canyon, some 80 miles south of the park. Riparian species occurring at some or all of these springs include *Acer negundo, Rhamnus begulaefolia, Bebula occidentalis, Cornus stolonifera* and *Rhus glabra.*

Riparian vegetation occurring along the Colorado River was not mapped in this study. A map of riparian vegetation along the river which occurs as strands of considerable extent consisting of *Acacia greggii, Prosopis juliflora, Baccharis* spp., *Salix* spp., and *Tamarix chinensis,* was produced by Phillips et al. (1977).

223.2121

Name: *Populus fremontii - Brickellia longifolia - Acacia greggii - Fallugia paradoxa* (Cottonwood - Brickellia - Catclaw Acacia - Apache plume)

Distribution: Elevational range is 1 700 to 5,600 feet (520 to 1,710 meters). The type is found on low slopes, up to 5 percent but may be steeper at mouths of springs (i.e., Thunder River), on all aspects. Soils may be gravelly streambed alluvium, or silty floodplain soil, with cobbles and gravel depending upon location relative to the stream channel. The type is found in drainages and side canyons with perennial water flow throughout the inner canyon, commonly beginning below the Redwall Limestone on terrace situations. Notable localities of the type occur in Nankoweap Creek, Clear Creek, Grapevine Canyon, Bright Angel Creek, Indian Gardens, Thunder River, Deer Creek and Havasu Creek.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (16)
Populus fremontii	cottonwood	2 - 5	3.2	0.7
Brickellia longifolia	brickellia	2 - 5	3.5	0.5
Acacia greggii	catclaw acacia	2 - 4	3.0	0.5
Fallugia paradoxa	Apache plume	1 - 4	2.5	0.5
Associated Species				
Quercus turbinella	scrub oak	2 - 5	3.8	0.4
Salix spp. (S. exigua, S. goodingii)	willow	3 - 4	3.2	0.4
Cercis occidentalis	red-bud	1 - 3	2.0	0.4
Artemisia dracunculoides	———	2 - 3	2.5	0.4
Bromus rubens	red brome	2 - 3	2.5	0.4
Artemisia ludoviciana	worm-wood	1 - 3	2.0	0.4
Agave utahensis	Utah agave	1 - 3	1.6	0.4
Gutierrezia sarothrae	snakeweed	2 - 3	2.6	0.4
Juniperus osteosperma	Utah juniper	2 - 3	2.2	0.3
Baccharis emoryi	Emory baccharis	2 - 4	2.6	0.3
Rhus trilobata	skunkbush	2 - 3	2.4	0.3
Vitis arizonica	canyon grape	2 - 4	3.0	0.2
Mimulus cardinalis	monkey-flower	2 - 3	2.3	0.2
Prosopis glandulosa	mesquite	2 - 4	3.0	0.2
Tamarix sp.	tamarisk	2 - 3	2.2	0.2

Occasional Species: *Stephanomaria* sp., *Typha domingensis, Phragmites communis, Ptelea trifoliata, Acer negundo, Nolina microcarpa, Alnus oblongifolia, Fraxinus* sp., *Pluchea sericea, Baccharis sarothroides, Adiantum venis-capellum, Maurandya antirhinifolia, Acourtia wrightii.*

Physiognomy: Broad-leaved deciduous gallery forest, in open or closed stands. Deciduous or sclerophyll shrubs or trees occur in the understory. Vines or herbs and grasses may form dense ground cover in less heavily impacted areas. Trees may reach 50 feet (15 meters) tall. Shrubs are up to 8 feet (2.4 meters) tall. Estimated total cover ranges from 35 to 80 percent. The floristic diversity in these wetland areas is extremely high in comparison to surrounding upland vegetation. Species composition also varies from one site to another depending on elevation, geographic location within the canyon, extent of floodplain or alluvial habitat, and hydrologic regime of the riparian system.

Figure 26. *Populus fremontii - Brickellia longifolia -Acacia greggii - Fallugia paradoxa* (223.2121) located along Thunder River. This type is usually found along water-courses with perennial flow. This site is unusually rich in deciduous species.

253.4221

Name: *Acacia greggii - Baccharis spp. - Fallugia paradoxa*
(Catclaw Acacia - Baccharis - Apache Plume)

Distribution: Elevational range is 1,500 to 5,200 feet (460 to 1,580 meters). This type occurs along drainages and washes and on adjacent floodplains. Soils are alluvial, commonly of gravelly, sandy, or cobbly texture, but occasionally of sandy loam. The type occurs throughout the canyon at or below the Redwall Limestone and extending to the River. This type includes all dry riparian washes and intermittent water-courses found in side canyons throughout the park.

Floristics:

		Prominence		
Characteristic Species		**Range**	**Mean**	**Frequency** (46)
Acacia greggii	catclaw acacia	2 - 5	3.2	0.7
Baccharis spp.	baccharis	2 - 5	3.1	0.5
Fallugia paradoxa	Apache plume	2 - 4	3.0	0.4
Ephedra spp.	Mormon tea	1 - 4	2.5	0.6
Gutierrezia sarothrae	snakeweed	2 - 5	2.7	0.5
Associated Species				
Bromus rubens	red brome	1 - 4	2.8	0.4
Bebbia juncea	sweet-bush	2 - 4	2.9	0.3
Encelia farinosa	brittlebush	1 - 3	2.6	0.3
Atriplex canescens	four-wing saltbush	1 - 4	2.7	0.2
Tamarix sp.	tamarisk	1 - 3	2.6	0.2
Populus fremontii	cottonwood	1 - 3	2.3	0.2
Chrysothamnus sp.	rabbitbrush	2 - 3	2.3	0.3
Cercis occidentalis	red-bud	1 - 4	2.1	0.3
Agave utahensis	Utah agave	1 - 3	2.0	0.3
Rhus trilobata	skunkbush	1 - 3	2.0	0.2

Occasional Sepcies: Nearly every species found in upland vegetation types is ocasionally present in dry riparian washes. Species listed here are those most specific to arroyos, washes and drainage habitats. *Brickellia longifolia, Haplopappus heterophyllous, Prosopis glandulosa, Porophyllum gracile, Artemisia dracunculoides, Populus fremontii, Vitis arizonica, Pluchea sericea, Trixis californica, Celtis pallida, Mimulus cardinalis, Cucurbita foetidissima.*

Physiognomy: Microphyll deciduous trees and mixed sclerophyll shrubs in open scattered and irregular stands, but sometimes forming thickets. Upland species from nearby vegetation types may also be present. Vines, grasses, herbs, succulents, and taller trees may also occur. Species composition is different in every wash, depending on relative moisture availability, elevation, and geographic location. Estimated total cover ranges from 15 to 100 percent (Fig. 27).

Figure 27. *Acacia greggii* - *Baccharis* spp. - *Fallugia paradoxa* (253.4221) located in Boulder Canyon. *A. greggii* and *F. paradoxa* occurs in thickets along the banks of this open, gravelly drainage channel, with *Artemisia dracunculoides* in the wash (foreground).

LITERATURE CITED

Babcock, R.S., E.H. Brown and M.D. Clark. 1976. Geology of the older Precambrian rocks of the Upper Granite Gorge of the Grand Canyon. In W.J. Breed and E. Roat, eds., Geology of the Grand Canyon. Museum of Northern Arizona, Flagstaff.

Beatley, J.C. 1975. Climates and vegetation pattern across the Mojave/Great Basin desert transition of Southern Nevada. The American Midland Naturalist 93:53-70.

Behle, W.H., J.B. Bushman and C.M. Greenhalgh. 1958. Birds of the Kanab area and adjacent high plateaus of southern Utah. University of Utah Biology Series 11:1-92.

Bradfield, M. 1974. Birds of the Hopi region, their Hopi names, and notes on their ecology. Museum of Northern Arizona Bulletin Number 48, Flagstaff.

Bradley, W.G. and J.E. Deacon. 1967. The biotic communities of southern Nevada. Nevada State Museum. Anthropology Paper Number 14:201-295.

Brown, B.T., K.A. Butterfield, R.R. Johnson and M.S. Moran. 1980. An inventory and classification of surface water resources in Grand Canyon National Park, Arizona. Pages 422-432 in Proceedings of the Second Conference on Scientific Research in the National Parks, Vol. 7: Ecosystem Studies. USDI National Park Service, Washington, DC.

Brown, D.E., C.H. Lowe and C.P. Pase. 1979. A digitized classification system for the biotic communties of North America, with community (series) and association examples for the Southwest. Journal of the Arizona-Nevada Academy of Science, Vol. 14, Supplement 1.

Carothers, S.W. and S.W. Aitchison, ed. 1976. An ecological survey of the riparian zone of the Colorado River between Lees Ferry and the Grand Wash Cliffs. Colo. R. Technical Report Number 10, Grand Canyon National Park, Arizona.

Carothers, S.W., S.W. Aitchison and R.R. Johnson. 1979. Natural resources, white water recreation, and river management alternatives on the Colorado River, Grand Canyon National Park. In Proceedings of the First Conference on Scientific Research in the National Parks. USDI National Park Service, Washington, DC, 1:253-259.

Clover, E.V. and L. Jotter. 1944. Floristic studies in the Canyon of the Colorado and tributaries. The American Midland Naturalist 32:591-642.

Cole, K.L. 1981. Late Quaternary environments in the eastern Grand Canyon: Vegetational gradients over the last 25,000 years. Ph.D. dissertation, University of Arizona, Tucson.

Cronquist, A., A.H. Holmgren, N.H. Holmgren and J.L. Reveal. 1972. Intermountain flora: vascular plants of the Intermountain West, U.S.A., Volume I. New York: Hafner Publishing Company.

Daubenmire, R.F. 1943. Vegetational zonation in the Rocky Mountains. Botanical Review 9:325-393.

Dolan, R., A. Howard and A. Gallenson. 1974. Man's impact on the Colorado River in the Grand Canyon. American Scientist 62:392-401.

Dye, A.J. and W.H. Moir. 1977. Spruce-fir forest at its southern distribution in the Rocky Mountains, New Mexico. American Midland Naturalist 97:133-146.

Ford, T.D. and W.J. Breed. 1976. The younger Precambrian rocks of the Grand Canyon. In W.J. Breed and E. Roat, eds., Geology of the Grand Canyon. Museum of Northern Arizona, Flagstaff.

Halvorson, W.H. 1972. Environmental influence on the pattern of plant communities along the North Rim of Grand Canyon. The American Midland Naturalist 87:222-235.

Irvine, J.R. and N.E. West. 1979. Riparian tree species distribution and succession along the lower Escalante River, Utah. Southwestern Naturalist 24: 331-346.

Jameson, D.A., J.A. Williams and E.W. Wilton. 1962. Vegetation and soils of Fishtail Mesa. Ecology 43:403-409.

Johnson, J.R. et al. 1974. Inventory and monitoring of natural vegetation and related resources in an arid environment; an evaluation of ERTS-1 imagery. NASA Goddard Space Flight Center. Greenbelt, Maryland. Final Report Type III, NASA Contract 5-21831.

Johnson, R.R. 1977. Synthesis and management implications of the Colorado River Research Program. Colorado River Technical Report Number 17, Grand Canyon National Park, Arizona.

Kuchler, A.W. 1977. The map of the natural vegetation of California in M.G. Barbour and J. Major, eds., Terrestrial Vegetation of California. John Wiley and Sons, New York.

Layser, E.F. and G.H. Schubert. 1979. Preliminary classification for the coniferous forest and woodland series of Arizona and New Mexico. Research Paper RM-208, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Lehr, J.H. 1978. A catalogue of the flora of Arizona. Desert Botanical Garden, Phoenix, Arizona.

McDougall. 1973. Seed plants of northern Arizona. Museum of Northern Arizona, Flagstaff.

Merkle, J. 1952. An analysis of a pinyon-juniper community at Grand Canyon, Arizona. Ecology 33:375-384.

——. 1954. An analysis of the spruce-fir community of the Kaibab Plateau, Arizona. Ecology 35:316-322.

——. 1962. Plant communities of the Grand Canyon area, Arizona. Ecology 43:698-711.

Merriam, C.H. 1890. Results of a biological survey of the San Francisco Mountain region and desert of the Little Colorado, Arizona. USDA North American Fauna No. 3. Government Printing Office, Washington, D.C.

Moir, W.H. and J.A. Ludwig. 1979. A classification of spruce-fir and mixed conifer habitat types of Arizona and New Mexico. Research Paper RM-207, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Mouat, D.A., J.B. Bale, K.E. Foster and B.D. Treadwell. 1981. The use of remote sensing for an integrated inventory of a semi-arid area. Journal of Arid Environments 4:169-179.

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

Phillips, A.M., III. 1975. Flora of the Rampart Cave Area, Lower Grand Canyon, Arizona. Journal of the Arizona Academy of Science 10:148-158.

——. 1977. Packrats, plants, and the Pleistocene in the lower Grand Canyon. Ph.D. Dissertation, University of Arizona, Tucson.

Phillips, A.M., III and B.G. Phillips. 1979. Vegetation and flora of Grand Canyon National Park, Arizona. Proceedings of the Second Conference on Scientific Research in the National Parks, San Francisco, 1979. 4: 203-221. National Technical Information Service, Springfield, Virginia.

Phillips, B.G., A.M. Phillips, M.E. Theroux and J.M. Downs. 1977. Map of the riparian vegetation of Grand Canyon National Park, Arizona. Final Research Report submitted to the U.S. National Park Service, Grand Canyon National Park.

Phillips, B.G., R.R. Johnson, A.M. Phillips and J.E. Bowers. 1979. Resource values of the aquatic and riparian vegetation of Roaring Springs, Grand Canyon. Pages 141-155 in Proceedings of the Second Conference on Scientific Research in the National Parks, Vol. 4: Resource Analysis and Mapping. USDI National Park Service, Washington, DC.

Poulton, C.E., D.P. Faulkner and N.L. Martin. 1971. Application of ecology and remote sensing in the analysis of range watersheds. Final Project Report, Range Management Program, Agricultural Experiment Station, Oregon State University, Corvallis.

Rasmussen, D.I. 1941. Biotic communities of Kaibab Plateau, Arizona. Ecological Monographs 11:230-273.

Schmutz, E.M., C.C. Michaels and B.I. Judd. 1967. Boysag Point: A relict area on the North Rim of the Grand Canyon in Arizona. Journal of Range Management 20:363-369.

Sellers, W.D. and R.H. Hill. 1974. Arizona climate 1931-1972. The University of Arizona Press, Tucson, Arizona.

Shimwell, D.W. 1971. The description and classification of vegetation. University of Washington Press, Seattle.

Shreve, 1942. The desert vegetation of North America. Botanical Review 8:195-246.

Shreve, F. 1964. Vegetation of the Sonoran Desert. In: F. Shreve and I.L. Wiggins, Vegetation and Flora of the Sonoran Desert. Stanford University Press.

Society of American Foresters. 1964. Forest cover types of North America. Washington DC.

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

Turnage, W.V. and A.L. Hinckley. 1938. Freezing weather in relation to plant distribution in the Sonoran Desert. Ecological Monographs 8:529-550.

Turner, R.M. and M.M. Karpiscak. 1980. Recent vegetation changes along the Colorado River between Glen Canyon Dam and Lake Mead, Arizona. Geological Survey Professional Paper 1132, United States Government Printing Office, Washington.

Van Devender, T.R. and J.I. Mead. 1976. Late Pleistocene and modern plant communities of Shinuno Creek and Peach Springs Wash, Lower Grand Canyon, Arizona. Journal of the Arizona Academy of Science 11: 16-22.

Warren P.L., B.K. Mortensen, B.D. Treadwell, J.E. Bowers and K.L. Reichhardt. 1981. Vegetation of Organ Pipe Cactus National Monument. Cooperative National Park Resources Studies Unit Technical Report No. 7.

Woodbury, A.M., ed. 1959. Ecological studies of the flora and fauna in Glen Canyon. University Utah Anthropology Paper Number 40 (Glen Canyon Series Number 7), University of Utah Press, Salt Lake City.

Woodbury, A.M., S.D. Durrant and S. Flowers. 1959. Survey of vegetation in the Glen Canyon Reservoir basin. University Utah Anthropology Paper Number 36 (Glen Canyon Series Number 5), University Utah Press, Salt Lake City.

Woodbury, A.M. and H.N. Russell Jr. 1945. Birds of the Navajo country. University of Utah Biology Series 9:1-157.

APPENDIX

Scientific and common names of plants encountered during vegetation mapping at G.C.N.P.. This list emphasizes perennial species, but a few abundant annual species are also included.

Abies concolor	white fir
A. lasiocarpa	alpine fir
Abronia nana	sand verbena
Acacia greggii	catclaw acacia
Acer grandidentatum	bigtooth maple
A. negundo	box elder
Achillea lanulosa	yarrow
Acourtia wrightii	desert holly
Actea arguta	baneberry
Adiantum venis-capellum	maiden hair fern
Agastache pallidiflora	giant hyssop
Agave utahensis	Utah agave
Agoseris glauca	mountain dandelion
Agropyron smithii	Western wheatgrass
A. subsecundum	bearded wheatgrass
Agrostis semiverticillata	water bentgrass
Allionia incarnata	trailing four-o'clock
Alnus oblongifolia	Arizona alder
Aloysia wrightii	oreganillo
Ambrosia dumosa	white bursage
Amelanchier utahensis	service berry
Amsinckia intermedia	coast fiddleneck
Amsonia brevifolia	blue star
Androsace septentrionalis	rock jasmine
Anulocaulis leisolenus	ringstem
Arctomecon californica	desert poppy
Arctostaphylos pungens	manzanita
Arenaria fendleri	sandwort

Aristida spp.	three-awn
Artemisia bigelovii	sagebrush
A. caruthii	sagebrush
A. dracunculoides	
A. ludoviciana	wormwood
A. nova	sagebrush
A. pacifica	sagebrush
A. tridentata	big sagebrush
Asclepius asperula	milkweed
Aster abatus	aster
A. adenolepis	aster
A. commutatus	white prairie daisy
A. foliaceous	aster
Astragalus praelongus	locoweed
Atriplex canescens	four-wing saltbush
A. confertifolia	shad scale
A. hymeneletra	desert holly
Baccharis salicifolia	seep-willow
B. sarothroides	desert broom
B. sergilloides	waterweed
Bebbia juncea	sweetbush
Berberis fremontii	desert barberry
B. repens	creeping mahonia
Bernardia incana	
Blepharoneuron tricholepis	hairy dropseed
Bouteloua chondrosioides	spruce-top grama
B. curtipendula	side-oats grama
B. gracilis	blue grama
B. eriopoda	black grama
Brickellia atractyloides	
B. longifolia	
Bromus arizonicus	Arizona brome
B. marginatus	brome
B. rubens	red brome
B. tectorum	cheat grass

Calamagrostis sp.	reed grass
Calochortus flexuosus	mariposa
Calycoseris parryi	yellow tack-stem
Campanula parryi	bellflower
Canotia holocantha	crucifixion thorn
Capsella bursa-pastoris	shepherds purse
Carex athrostachya	sedge
C. occidentalis	sedge
C. subfusca	sedge
C. vesicaria	inflated sedge
Cassia covesii	desert senna
Castilleja confusa	paint-brush
Ceanothus fendleri	buck-brush
C. greggii	desert deer-brush
Celtis pallida	desert hackberry
C. reticulata	net-leaf hackberry
Centaurium calycosum	canchalagua
Cercis occidentalis	red-bud
Cercocarpus intricatus	little-leaf mountain-mahogany
C. ledifolius	mountain-mahogany
C. montanus	alder-leaf mountain-mahogany
Chamaebatiaria millefolia	fernbush
Chaenactis macrantha	
C. stevioides	Esteve pincushion
Chrysopis villosa	hairy golden-aster
Chrysothamnus depressus	rabbitbrush
C. nauseosus	rabbitbrush
C. viscidiflorus	sticky-leaved rabbitbrush
C. parryi	rabbitbrush
Cirsium drummondii	thistle
Cleome lutea	yellow bee-plant
Coleogyne ramosissima	blackbrush
Collomia linearis	
Commandra pallida	bastard toadflax
Cordylanthus parviflorus	birdbeak

Coryphantha vivipara	
Cryptantha capitata	
C. setosissima	
Cowania mexicana	cliffrose
Cucurbita foetidissima	buffalo gourd
Cymopterus multinervatus	purple cymopterus
Dactylis glomerata	orchard grass
Dalea fremontii	indigo bush
Danthonia intermedia	timber oatgrass
Delphinium sp.	larkspur
Deschampsia caespitosa	tufted hairgrass
Dyssodia acerosa	dogweed
D. pentachaeta	dogweed
Echinocactus polycephalus	manyhead cactus
Echinocereus englemannii	hedgehog cactus
E. triglochidiatus	hedgehog cactus
Eleocharis acicularis	spike rush
Encelia farinosa	brittlebush
E. frutescens	rayless encelia
Enceliopsis argophylla	
Ephedra nevadensis	joint-fir, Mormon tea
E. torreyana	Torrey joint-fir
E. viridis	mountain joint-fir
Epilobium californicum	fire-weed
Erigeron flagellaris	running fleabane
E. formosissimus	fleabane
Eriogonum corymbosum	wild buckwheat
E. fasciculatum	wild buckwheat
E. heermannii	Hermann buckwheat
E. inflatum	desert trumpet
E. jamesii	antelope sage
E. mearnsii	wild buckwheat
E. racemosum	red-root buckwheat
E. simpsonii	wild buckwheat

E. wrightii	Wright buckwheat
Erioneuron pulchellum	desert fluffgrass
Erodium cicutarum	starks-bill filaree
E. texanum	large-flower storks-bill
Erysimum repandum	wall flower
Eucnide urens	rock-nettle
Eurotia lanata	winterfat
Fallugia paradoxa	Apache-plume
Fendlera rupicola	fendlerbush
Fendlerella utahensis	
Ferocactus acanthodes	barrel cactus
Festuca octoflora	fescue
Fouquieria splendens	ocotillo
Fragaria sp.	strawberry
Fraxinus anomala	single-leaf ash
F. cuspidata	flowering ash
F. velutina	velvet ash
Gaillardia parryi	blanket-flower
Galium stellatum	bedstraw
Garrya flavescens	silk tassel
G. wrightii	silk tassel
Gentiana parryi	gentian
G. strictiflora	gentian
Gilia tenuituba	
Geranium eremophilum	crane's-bill
G. richardsonii	crane's-bill
Glossopetalon nevadense	grease-bush
Gutierrezia sarothrae	snakeweed
Haplopappus heterophyllus	jimmy weed
H. spinulosus	
Helianthella quinquenervis	
Hilaria rigida	big galleta
Holodiscus dumosus	rock spiraea

Hymenoclea salsola	cheese-bush, burrobush
Hymenoxys subintegra	bitterweed
Hypericum formosum	St. John's wort
Janusia gracilis	
Juniperus communis	dwarf juniper
J. monosperma	one-seed juniper
J. osteosperma	Utah juniper
Koeleria cristata	june-grass
Krameria parvifolia	range ratany
Larrea tridentata	creosote-bush
Lesquerella arizonica	bladder-pod
Linum lewisii	flax
Lotus utahensis	deer vetch
Lupinus hillii	lupine
Lycium andersonii	wolf-berry
L. pallidum	rabbit-thorn
Madia glomerata	tarweed
Mammillaria tetrancistra	fishhook cactus
Maurandya antirhiniflora	twining snapdragon
Melampodium leucanthum	black-foot
Menodora scabra	twin-berry
Mentha arvensis	field mint
Mentzelia pumila	blazing star
Mertensia fransiscana	bluebells
Mimulus cardinalis	monkey-flower
Mirabilis multiflora	Colorado four-o'clock
M. bigelovii	wishbone bush
Montia perfoliata	miner's lettuce
Mortonia scabrella	sandpaper bush
Muhlenbergia montana	mountain muhly

Neolloydia johnsonii	beehive cactus
Nicotiana trigonophylla	desert tobacco
Nolina microcarpa	bear-grass
Notholaena sinuata	wavy cloak-fern
Opuntia acanthocarpa	buckhorn cholla
O. basilaris	beavertail cactus
O. chlorotica	pancake pear
O. erinacea	Mohave prickly-pear
O. phaeacantha	prickly-pear cactus
O. polycantha	plains prickly-pear
O. whipplei	Whipple cholla
Orthocarpus luteus	yellow owl-clover
O. purpureo-albus	owl-clover
Oryzopsis hymenoides	Indian rice-grass
Ostrya knowltonii	hop hornbeam
Oxybaphus comatus	
Parthenium incanum	mariola
Pedicularis centranthera	lousewort
Pellea longimucronata	cliff-brake
Penstemon barbatus	beard-tongue
P. pachyphyllus	beard-tongue
P. parryi	beard-tongue
P. utahensis	Utah firecracker
P. virgatus	beard-tongue
Perideridia parishii	
Perityle emoryi	Emory rock-daisy
Petalonyx sp.	sandpaper plant
Petrophytum caespitosum	rock-mat
Peucephyllum schottii	desert fir
Phacelia crenulata	
P. magellanica	
P. pulchella	
Phleum pratense	common timothy
Phlox austromontana	

P. longifolia	
Phragmites communis	
Picea englemannii	Englemann spruce
Pinus edulis	pinyon pine
P. ponderosa	ponderosa pine
Plantago insularis	wooly plantain
Pluchea purpurascens	marsh fleabane
Poa arida	plains bluegrass
P. fendleriana	mutton-grass
P. pratensis	Kentucky bluegrass
Polygonum amphibium	water smartweed
P. douglasii	
P. sawatchense	
Populus fremontii	cottonwood
P. tremuloides	quaking aspen
Porophyllum gracile	slender pore-leaf
Potentilla glandulosa	cinque foil
P. hippiana	cinque foil
P. norvegica	rough cinque foil
P. osterhoutii	cinque foil
Prosopis glandulosa	mesquite
Prunella vulgaris	heal-all
Prunus fasciculata	desert almond
Pseudocymopterus montanus	mountain parsley
Pseudotsuga menziesii	Douglas fir
Psilostrophe sparsiflora	paper-flower
Ptelea trifoliata	hop-tree
Pteridium aquilinum	bracken
Purshia tridentata	antelope-brush
Pyrola picta	wintergreen
Quercus gambelii	Gambel oak
Q. turbinella	scrub oak
Q. undulata	wavey-leaf oak

Ranunculus cardiophyllus	buttercup
R. flammula	buttercup
Rhamnus betulaefolia	birch-leaf buckthorn
Ribes montigenum	gooseberry currant
R. viscosissimum	sticky currant
Rhus trilobata	skunkbush
Robinia neomexicana	New Mexico locust
Rosa arizonica	rose
R. stellata	rose
Rubus parviflorus	thimbleberry
Rumex acetosella	sheep sorrel
R. californicus	dock
Salazaria mexicana	bladder-sage
Salix bebbiana	Bebb willow
S. exigua	coyote willow
S. goodingii	Gooding willow
Salsola kali	tumbleweed, Russian thistle
Salvia carnosa	desert sage
Sambucus neomexicana	elderberry
Senecio sp.	groundsel
Silene scouleri	catchfly
Sitanion hystrix	squirrel-tail
Shepherdia rotundifolia	buffalo-berry
Smilacina stellata	starflower
Solidago ciliosa	goldenrod
S. sparsiflora	goldenrod
Sphaeralcea ambigua	desert globe-mallow
Stephanomeria sp.	wire-lettuce
Stipa arida	needle-grass
S. comata	needle-and-thread
S. lettermanii	Letterman needle-grass
S. speciosa	desert needle-grass
Suaeda torreyana	desert seepweed
Symphoricarpos rotundifolius	snow-berry

Tamarix chinensis	salt-cedar
Tetradymia axillaris	cotton-thorn
Thalictrum sp.	meadow rue
Thamnosma montana	turpentine broom
Tiquilia latior	
Townsendia millefolium	
Trifolium pinetorum	clover
Trisetum montanum	
Trixis californica	
Typha domingensis	cattail
Viguiera multiflora	golden-eye
Vitis arizonica	canyon grape
Yucca angustissima	soap-weed
Y. baccata	banana yucca
Y. brevifolia	joshua tree
Y. shidigera	spanish dagger
Y. whipplei	Our-Lord's-candle
Zigadenus paniculatus	death camas, sard corn
Zizyphus obtusifolia	gray-thorn