

**AN ECOLOGICAL ASSESSMENT OF
THE SHIVWITS PLATEAU REGION**

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EXECUTIVE SUMMARY

Introduction

The Shivwits Plateau region includes a vast tableland and adjacent low desert lying north of western Grand Canyon in northwestern Arizona (Fig. 1). The eastern and western edges of the Shivwits Plateau form dramatic escarpments, and one of the nation's most remarkable ecotones (zones of ecological transition). This peninsular plateau region lies on the southwestern Colorado Plateau bordering the Grand Canyon and Lake Mead to the south; extending to the top of the Hurricane Cliffs to the east, including the Mt. Trumbull/Logan area of the southern Uinkaret Plateau; and down into the Mojave Desert to the west. The Shivwits Plateau extends north through a line of low volcanic mountains to the St. George basin boundary. This northern part of the Shivwits forms a rugged expanse adjoining the Virgin Mountains and the Paiute Wilderness Area.

Most of the 1,131,200 ha (2,800,000 ac) Shivwits Plateau lies at elevations of 1,500 to 2,000 m, and is a relatively flat surface, sloping gently down to the north, with a capping veneer of basalt flows and several volcanic peaks. The Grand Wash Cliffs, middle elevation Sanup Plateau, and low desert in Grand Wash form ecotonal steps between the eastern Mojave/Sonoran/Great Basin deserts and the boreal woodlands and forests of the Shivwits Plateau. The Shivwits Plateau region is of considerable scientific interest as a natural laboratory in which to study geological processes, climate change, ecotone ecology, and restoration ecology, and the area has tremendous scenic value along its eastern, southern and western escarpments.

This landscape is nearly entirely federally managed by the National Park Service, to the south, and the Bureau of Land Management to the north. The U.S. Fish and Wildlife Service has administrative responsibility over the region's biota, particularly endangered species. The Arizona Game and Fish Department has wildlife management jurisdiction. Some private in-holdings exist, particularly at the townsite of Mount Trumbull and several mining claims. In 1998, the U.S. Bureau of Land Management produced a draft map of a proposed national monument on the southern end of the Shivwits Plateau. Several areas of potential scientific and conservation value lay outside the originally proposed boundaries, including: the Poverty Mountain area, the northern half of the Shivwits Plateau and Hurricane Cliffs, and the Arizona Strip between Grand Wash and the Grand Wash Cliffs. Addition of those lands would contribute to the protection of the long escarpment ecosystems, several large undeveloped springs, and conservation lands that provide desert tortoise (*Gopherus agassizi*), desert bighorn sheep (*Ovis canadensis nelsoni*) and pronghorn (*Antilocapra americana*) habitat, and potentially migratory hawks and other raptors, as well as waterbirds using upper Lake Mead. Recently, the Secretary of the Interior recommended expansion of the original boundaries to include several of these features, and to improve landscape connectivity.

Grand Canyon Wildlands Council is a consortium of scientists and conservationists which promotes applying the best scientific information to landscape conservation in the ecoregion surrounding Grand Canyon. Following public meetings on the proposed Shivwits National Monument, and in response to what we perceived as a limited synthesis of information, we elected to conduct a more detailed analysis of the existing physical, biological and cultural data on the Shivwits Plateau region. Our effort augments excellent syntheses by individual federal and state

managing agencies (*e.g.*, U.S. Bureau of Land Management 1990, 1992; U.S. Bureau of Land Management and Arizona Game and Fish Department 1991; U.S. National Park Service 1981), and strives to incorporate their reports and scientific studies over the past century into a single overview of the Shivwits Plateau region.

The information summarized here, and presented in detail in the full report, identifies nine outstanding characteristics of the Shivwits Plateau region, including: 1) its position encompassing the continentally significant boundary between the Basin and Range and the Colorado Plateau Geologic Provinces; 2) its paleoecological significance as a landscape demonstrating vegetation responses to global climate change over the past 50,000 years, and which has produced a world-class stepped ecotone along the Grand Wash Cliffs; 3) its value as a refuge for endemic species and 4) for sensitive and game species; 5) its two large north-south escarpments, which may serve as a corridor for migratory raptors and other species; 6) its scientific and management value in wildlife population and landscape restoration; 7) nearly 8000 years of occupation by American Indians; 8) its colorful human history since 1776; and 9) its vast, rarely-visited and little-developed character with tremendous scenic value. The geographic area encompassing these features includes the Interior Secretary's current approximately 1 million acre proposal along with additional lands north and east. The nine elements are described below.

A Remarkable Geologic Boundary

The Shivwits Plateau region spans one of the most profound geological boundaries in the United States, bridging the Basin and Range Geologic Province with the Colorado Plateau to the east. The intensely faulted Basin and Range is the only active rift on earth not under water, and lies beside the uplifted but nearly unbroken Colorado Plateau. The transition between these two geologic provinces is exquisitely exposed, providing geologists with evidence of the dynamics of geological processes. In recent geologic time, the crustal extension expressed in the Basin and Range province has begun to stretch the western margin of the Colorado Plateau. This has resulted in a series of long parallel, curvilinear faults and associated cliffs, slicing north to south through the Shivwits Plateau region. At the plateau's western edge, the Grand Wash fault juxtaposes the colorful, lava-capped Precambrian and Paleozoic strata of the Grand Canyon against the highly faulted terrain, recent lake beds, and desert volcanic peaks of the downdropped Grand Wash trough. This region holds the key to the geological interaction of these two great provinces and the landscape evolution of the lower Colorado River.

The Shivwits Plateau region reveals much about the development of Grand Canyon. Uplift of the southern margin of the Colorado Plateau likely reversed drainage directions and allowed the Colorado River to cut across the terrain. The Colorado River system integrated with the developing Gulf of California, creating a through-flowing river. The timing of canyon cutting is recorded in the volcanic rocks and alluvial fans of the Shivwits Plateau and Grand Wash Trough respectively. Despite years of study, there is still much to be learned about the timing and evolution of the Colorado River and Grand Canyon, and the critical data lie, at least in part, on the Shivwits Plateau.

Climate Change and Ecotone Ecology in a Natural Laboratory

Dramatic Changes: A remarkable paleoecological transformation of the Shivwits Plateau ecotone has occurred over the past 50,000 years. The western margin of the Shivwits Plateau marks the boundary between the Sonoran/ Mojave/Great Basin floristic provinces to the west, with the Maderan province to the south, and the Intermountain province to the northeast. Analysis of ancient packrat middens and cave deposits has revealed that the pinyon-juniper treeline rose 3,000 feet upslope in less than 7,000 years during the Pleistocene-Holocene transition, as a warmer, drier climate developed. These environmental shifts resulted in the mixing of plant species from the surrounding ecosystems and biomes. Environmental and floristic changes, coupled with the arrival of early humans, resulted in the extinction of the Pleistocene megafauna – elephants, camels, mountain goats, large predators, and giant birds that roamed the plateaus and lowlands, prior to natural desertification. Great concern exists regarding ecological processes and responses to global climate change, and the Shivwits Plateau region provides a unique natural laboratory in which to study and understand these changes.

Contemporary Ecosystems: Grand Wash, the Sanup Plateau and the Grand Wash Cliffs form one of the nation's most distinctive ecotones, an ecological transition from the Mojave Desert to boreal coniferous forests. The contemporary vegetation of the Shivwits region consists of several distinct assemblages: 1) desert creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*) in Grand Wash; 2) desert riparian Fremont cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*), and mesquite (*Prosopis glandulosa*) at springs; 3) a regionally unusual assemblage of Joshua tree (*Yucca brevifolia*), blackbrush (*Coleogyne ramosissima*), Utah juniper (*Juniperus osteosperma*) and cacti on the middle elevation Sanup Plateau; chaparral-oak shrub and woodland on south-facing slopes; 4) widespread stands of pinyon pine (*Pinus monophylla* and *P. edulis*) and Utah juniper in vast woodlands on the plateau; 5) remnant short-grass prairie to the north and east; 6) stands of bigtooth sagebrush (*Artemisia tridentata*) and snakeweed (*Gutierrezia sarothrae*) in natural and altered meadows, particularly on grazing-disturbed uplands; 7) ponderosa pine (*Pinus ponderosa*) at higher elevations; and 8) upland riparian vegetation around Plateau springs.

Biological Hotspots

Desert and plateau springs may be regionally important biological hot spots that protect endemic species. The BLM manages at least 43 springs on the southern half of the Shivwits Plateau, and Lake Mead National Recreation Area manages several dozen additional springs. Many of the BLM springs have been greatly altered by human activities, with discharge diverted or abstracted. Springs and seeps are hot spots for biodiversity: aquatic and land snails, pillbugs (Isopoda), *Hyallela* amphipids and various amphibians require spring habitats, and are prone to endemism in these habitats. For example, Tassi, Grapevine and Whiskey springs on Grand Wash support populations of numerous summer resident Neotropical songbird species, as well as woodpecker, Gambel quail and the endemic Grand Wash spring snail (Hydrobiidae: *Pyrgulopsis bacchus*). However, Shivwits Plateau and Grand Wash springs biota have not been systematically inventoried.

A Refuge for Sensitive and Game Species

The Shivwits Plateau region supports at least 232 plant species, at least one fish species, numerous but poorly documented amphibian and reptile species, 115 bird species, and 49 mammal species. A total of 59 (>5%) species that do or may occur in the region are recognized as rare and sensitive species of concern to the State of Arizona, the U.S. Fish and Wildlife Service, and other federal agencies. The extent of migratory and upland species using the Shivwits Plateau and its western periphery as winter range is presently unknown, but also may be of conservation interest. The northwestern portion of the Shivwits is managed as desert tortoise habitat. Game populations include wild turkey (*Meleagris gallopavo*), desert mule deer (*Odocoileus hemionus*), desert bighorn sheep, and pronghorn in this region. Winter waterbird populations (including bald eagle, *Haliaeetus leucocephalus*) on upper Lake Mead and its shorelines are substantial, but are poorly documented.

An Important Migratory Corridor?

Long, north-south aligned escarpments define the Shivwits Plateau, with the Grand Wash Cliffs on the west and the Hurricane Cliffs to the east. Long north-south aligned cliffs such as these commonly provide migratory pathways for hawks and other species. A large number of raptors migrate through southern Nevada and use upwardly-rising air currents that develop as daytime mountain winds along cliff lines. Although not well documented, our single reconnaissance in October 1999 detected at least 5 raptor species, with 0.1 raptors/km and 9 birds/hr. These preliminary data suggest use of the escarpments by raptors, but more thorough surveys are needed to provide better resolution of the extent, timing and daily variability of migratory species. The Shivwits region also may provide seasonal access corridors for large mammals, such as desert mule deer, desert bighorn sheep, and mountain lion (*Felis concolor*) from lowland to upland habitats, through drainages such as Pigeon and Hidden canyons; however, the movement patterns of large Shivwits Plateau mammals are poorly known.

Population and Landscape Restoration Ecology

Restoration ecology is being explored and implemented in the Shivwits region through several different projects. 1) The Mt. Trumbull Resource Conservation Area is a ponderosa pine forest in which fire suppression, grazing and logging have altered forest structure and composition. The pre-settlement fire frequency was 3-5 yr, but fire suppression has allowed fuel loads to accumulate, threatening this ecosystem with potentially devastating fires. The Mt. Trumbull RCA is being used to scientifically test forest restoration options in an interagency effort spearheaded by W.W. Covington and his associates at Northern Arizona University. 2) Eighteen young endangered California condors (*Gymnogyps californianus*) have been released from a site on the Hurricane Cliffs 36 miles south of St. George, UT as part of the on-going California condor re-introduction program, and additional releases are planned. 3) Pronghorn populations declined on the northern half of the Shivwits Plateau until the populations were augmented in the 1960's by the Arizona Game Fish Department. Pronghorn numbered 150-200 head in 1998, and the success of the pronghorn program has allowed the AGFD to issue hunting permits since 1977. The desert bighorn sheep population is increasing as well, as on-going collaboration between BLM and AGFD has initiated population augmentation in the northern

Shivwits region. 4) Non-native tamarisk, an invasive woody tree, has been removed from several desert springs along Grand Wash, a remarkably successful program lead by the National Park Service at Lake Mead National Recreation Area and underway by the BLM at several of its low elevation springs.

5) The desert tortoise is a focal species for habitat management along the western edge of the Shivwits Plateau. Several habitat conservation areas have been established and are being monitored by the BLM in St. George, Utah and the northern Sanup Plateau area may provide excellent habitat for desert tortoise, and is being managed for that species by the BLM. Overall, these population and ecosystem management activities demonstrate that the Shivwits region is an extraordinary natural laboratory in which to test and apply the principles of conservation and restoration ecology.

Archeology

Much of the current understanding of Shivwits Plateau region archeology is based on small-scale, superficial surveys, rather than on broad or detailed assessments. However, existing research has revealed Paleoindian artifacts dating to perhaps 6000 BC; quarries, campsites and chipping areas dating from the Archaic period (ca. 2500 to 300 BC), as well as numerous crescent-shaped pueblos with 12-20 rooms, field houses, check dams, other agricultural features, *Agave* roasting pits of the Basketmaker II to Pueblo III periods (ca. AD500-1150); and Southern Paiute occupation (ca. AD1250-1880). Pictograph sites, caves (including some with feathered arrowshafts, sandals, and woven baskets) and rockshelters containing elaborate rock art have been discovered. Preliminary data suggested that this region was primarily used for seasonal hunting and gathering, and was marginal for horticulture; however, subsequent and more intensive studies have documented extensive evidence of Puebloan agricultural activities and permanent habitations. Conservation and further inventory and study of these sites and remains will elucidate the complex relationships between early humans in the Shivwits Plateau and Grand Canyon regions. These sites and remains are considered by contemporary American Indians to be significant cultural properties.

Exploration and Settlement History

The color and harshness of the Shivwits Plateau region is strongly reflected in its exploration and settlement history. The Escalante-Dominguez Expedition of 1776 passed along the Hurricane Cliffs and made first contact with the Uinkaret Paiute Indians. Early mountain men and explorers, including Jedediah Smith (1826, 1827), Antonio Armijo (1829) and William Wolfskill (1830) were largely responsible for defining the Old Spanish Trail just north of the Shivwits Plateau, which subsequently became the most heavily used route for travelers from New Mexico to California. Mormon explorer Jacob Hamblin documented access routes and establish contact with resident Paiute Indians from 1858 through 1863. John Wesley Powell documented approximately 300 Paiutes in three bands in the region in 1874. Early cattle operations, such as that of James Whitmore, ended in disaster as raiding Navajos and Paiutes fought to regain lost lands; however, federal military actions and negotiations ended the Indian uprisings in the 1880's. Peace allowed small grazing operations to spring up, but cattle barons, such as B.F. Saunders and Preston Nutter, eventually took control of the water sources in the two decades before and after the turn of the 20th

century, forcing out many of the small cattle operations. A lumber mill was operated on Mt. Trumbull to provide lumber for the Mormon Temple in St. George, Utah, and later these highest peaks were commercially logged. The region's settlement history is also related to the flight of traditional Mormon families after polygamy was outlawed. The only significant settlement on the Shivwits Plateau was the town of Mt. Trumbull (or "Bundyville"), which once numbered nearly 300 residents, and lasted for five decades before the residents finally abandoned the harsh, waterless site. At present, Government Accounting Office data indicate that grazing contributes less than one percent of the employment in Washington and Kane counties, Utah, as well as in parts of Mohave and Coconino counties, Arizona. The largest commercial operation on the Shivwits Plateau is Tony Heaton's Bar Ten Ranch, a working ranch that provides transportation and accommodations for visitors emerging from or headed in to Grand Canyon river trips. In addition, several active mines exist on the Sanup Plateau.

A Vast, Scenic Landscape

The Shivwits Plateau region is a truly vast and largely undeveloped landscape. It is one of the least visited parts of the United States. The Hurricane Cliffs are one of the longest individual escarpments in North America, extending far north and south of the Shivwits region. Off the dramatic Grand Wash Cliffs to the west, the Sanup Plateau forms a world-class stepped ecotone. The Shivwits Plateau, its escarpment margins, and the surrounding lands, have exceptional regional and global scenic value, and are among the most remote lands remaining in the coterminous United States.

Summary

The Shivwits Plateau region appears to be worthy of, and available for, enhanced federal protection. Our landscape analysis indicates that significant geological, biological and human history features and processes exist in this region, and additional research may contribute substantial additional information to understanding the processes and impacts of geological, biogeographic and global environmental change. These objects, features, and scientific opportunities, coupled with the overall high ecological integrity of most of the landscape, its low human population density and development, and few extractable resources, make the Shivwits Plateau a reasonable target for increased protection. The region has outstanding scenic value, particularly its eastern, southern and western escarpments. Enhanced protection of the Shivwits Plateau region will help buffer Grand Canyon National Park from the impacts of rapid population expansion in southern Utah (i.e., St. George, Cedar City) and Nevada (Las Vegas, Mesquite). In addition, the recently revised expansion of the proposed monument boundaries would help protect and link the prominent north-south escarpments, springs and wildlife movement corridors, the Sanup Plateau and the Grand Wash drainage. The revised boundaries would provide for better landscape linkage among the region's four Wilderness Areas, and would protect additional desert tortoise, antelope, or desert bighorn sheep habitats on the northwestern Shivwits Plateau region. Much remains to be learned about the Shivwits Plateau region, and future inventories and studies are likely to substantially increase the list of species and identify important, as yet unrecognized, ecological processes. Such data are only likely to

further strengthen the rationale for preserving this geologically, biologically and anthropologically outstanding landscape

INTRODUCTION

A Vast, Rarely Visited Landscape

The Shivwits Plateau region includes the Shivwits Plateau (including the Hurricane Cliffs escarpment), the southwestern Uinkaret Plateau, the Sanup Plateau, the low desert lands of the Grand Wash drainage, and the lands to the south overlooking the Colorado River in Arizona (Fig. 1). The Shivwits Plateau itself is a vast, arid peninsula on the southwestern Colorado Plateau bordering the Grand Canyon and Lake Mead to the south and the Mojave Desert to the west. The western margin of the Shivwits Plateau forms a stepped ecological transition or ecotone bridging one of the most profound geological and biological boundaries in the United States. This ecotone forms the transition between the Colorado Plateau and Basin and Range Geologic provinces. Recent public discussions and proposals have been put forth concerning a possible new land conservation designation in the “Grand Canyon-Parashant National Monument”, which is included here within the Shivwits Plateau region. The area discussed here differs from the smaller monument originally proposed by the Bureau of Land Management in 1998 for reasons related to the distribution of sensitive species and game species, their habitats, archeological features and landscape continuity.

This report was prepared by Grand Canyon Wildlands Council, which is a consortium of scientists and conservationists whose aims are to promote the use of the best scientific information in landscape conservation on the southern Colorado Plateau. Following public meetings on the proposed Shivwits National Monument, and in response to what we perceived as a limited synthesis of information, we elected to conduct a more detailed analysis of the existing physical, biological and cultural data on the Shivwits Plateau region. Our efforts augment the excellent syntheses by individual federal and state managing agencies (*e.g.*, U.S. National Park Service 1981; U.S. Bureau of Land Management 1990, 1992; U.S. Bureau of Land Management and Arizona Game and Fish Department 1991), incorporating those reports with scientific studies over the past century into a single overview of the Shivwits Plateau region. The resulting report summarizes scientific information on the Shivwits Plateau region’s geography, geology, biology, archeology and history of the region. We describe the natural and cultural resources of the region, its escarpment steps and the surrounding lands, and the potential for developing further scientific understanding into regionally and globally important issues.

Nine features appear to be important for consideration of enhanced landscape protection in the Shivwits Plateau region. These include: 1) its position encompassing the continentally significant boundary between the Basin and Range and the Colorado Plateau Geologic Provinces; 2) its paleoecological significance as a landscape demonstrating how vegetation has responded to global climate change over the past 50,000 years, and which has produced a world-class stepped ecotone along the Grand Wash Cliffs; 3) its biological hotspots, such as springs, that support endemic species; 4) its function as a refuge that protects species of concern (*i.e.*, endangered species and game species); 5) its several large north-south escarpments, which may serve as a migratory corridor for raptors and other species; 6) its scientific and management value in wildlife population and landscape restoration; 7) its little explored but significant archeological resources; 8) its colorful human history since 1776; and 9) its vast, rarely-visited and little-developed character with tremendous scenic value. The region also is a largely undeveloped land area that buffers the western Grand Canyon and northern Lake Mead from the

rapidly expanding communities of southwestern Utah and southern Nevada. We discuss the regional and national scientific and cultural significance of these characteristics, as well as the region's scenic characteristics, its present ecological integrity, its population density and extent of development in the context of the proposed increase in federal landscape protection.

GEOGRAPHY

Plateaus, Escarpments, Canyons and Low Deserts

Most of the 1,131,200 ha (2,800,000 ac) Shivwits Plateau lies at elevations of 1,500 to 2,000 m, and is a relatively flat surface, sloping gently down to the north (Fig. 1). Various volcanic features form mountains, knolls, and ridges of moderate relief. Erosion along north-trending fault zones in the western Grand Canyon deeply dissects the Shivwits Plateau to the south in (from east to west) Toroweap, Whitmore, Andrus/Parashant, Surprise, Burnt, Tincanebitts, and Dry canyons. The Colorado Plateau and the Basin and Range geologic province are abruptly juxtaposed along the Grand Wash fault, creating a dramatic, 129 km-long escarpment extending north and south of the Colorado River. The Grand Wash Cliffs extend for more than 60 km along the western boundary of the Shivwits Plateau region. The rising prows of Snap Point, Mustang Point, Last Chance Knoll, and Link Point mark the emergence of Snap, Pigeon, Squaw, and Hidden canyons, respectively, from the Shivwits Plateau. Jump Canyon and Pocum Wash canyon emerge at the northernmost end of the Shivwits Plateau region along this impressive line of cliffs. The Sanup Plateau forms a platform between the upper and lower Grand Wash Cliffs, a middle elevation bench between the Shivwits Plateau and Grand Wash. Grand Wash is a large (approximately 100,000 ha), complex, ephemeral drainage fed by Pocum and Cottonwood washes east of the Cockscomb, and Black Wash to the west of that feature, with some of its basin in Nevada. Most of the Grand Wash drainage lies below 1000 m elevation, and it descends to below 360 m at Lake Mead.

The Shivwits Plateau region is bounded on the north by the St. George Basin. A series of small volcanic peaks of 1,400 m to 2,250 m lie immediately south of the basin and rise 500 m above the surrounding plains. They include from west to east: Mud, Black Rock, Mustang Knoll, Low, Mokaac, Quail Hill, Seegmiller and East Mesa mountains. The Shivwits Plateau is bounded on the east by the 150 km-long escarpment of the Hurricane Cliffs. At its southeastern corner, the Shivwits region includes a corner of the Uinkaret Plateau, just east of the Hurricane Cliffs and the Hurricane fault. Several volcanic peaks, including Kinney Peak, Bull Mountain, Slide Mountain, Mt. Logan, Mt. Emma, and Mt. Trumbull form the Sawmill and Uinkaret Mountains. The latter peak reaches 2,447 m and is the highest point in the Shivwits Plateau region. Southwest of Mt. Trumbull, Parashant Canyon has captured the majority of drainage off the Shivwits Plateau. Prior to the deepening of Grand Canyon, water exited the Shivwits Plateau by way of Hidden Canyon (G. Billingsley, personal communication). Hidden Canyon is an older canyon, much larger than would be predicted by today's ephemeral rainfall flood flows.

Land Management

The lands on the south end of the Shivwits Plateau are administered by the National Park Service (NPS; Grand Canyon National Park and Lake Mead National Recreation Area-LMNR)

and the Arizona Game and Fish Department (AGFD), while the Bureau of Land Management (BLM) administers most of the uplands to the north (U.S. Bureau of Land Management 1990, 1992; National Park Service 1981), as well as the Grand Wash drainage north of LMNRA. The U.S. Fish and Wildlife advises the other federal agencies regarding protection of threatened and endangered species. BLM jurisdiction of the Shivwits Plateau is authorized by the Federal Land Policy and Management Act of 1976. Private lands make up about 5% of the landscape, with holdings concentrated in the Upper Hurricane Valley/Mt. Trumbull townsite area, north of Mt. Dellenbaugh in Oak Grove and Penn Valley, north of Mt. Trumbull, and in the Whitmore Wash drainage.

The BLM considers areas of critical concern to include: the Beaver Dam Slope (for desert tortoise); the Virgin River Gorge (for scenic and riparian values); Ft. Pierce (for endangered cacti); Little Black Mountain, Witch Pool and Nampaweap (for cultural resources); and Lost Spring Mountain and Moonshine Ridge (for cultural resources and endangered cacti). In addition, Grapevine and other BLM-managed springs have been protected from grazing for several decades. BLM resource conservation areas include: the 15,000 ha Parashant drainage (for wildlife, scenic, recreation, grazing, and watershed values); and the 31,916 ha Mt. Trumbull area (for wildlife, scenic, recreation, cultural, ponderosa pine forest, grazing, and watershed values). The Shivwits Plateau region connects several Wilderness Areas and National Park Service and Bureau of Land Management protected land units, including: the Mt. Trumbull, Mt. Logan, Grand Wash Cliffs, and Paiute wilderness areas; Grand Canyon National Park, Lake Mead National Recreation Area, and the Grand Staircase-Escalante National Monument; and the Mt. Trumbull Resource Conservation Area.

Remoteness

The Shivwits Plateau region is remote both by virtue of its topographic variability, its isolation on the Arizona Strip north of the Colorado River, and because access into the region is restricted to dirt roads. From the west, the access into Grand Wash is via Nevada's Gold Butte or Lime Kiln roads onto the Grand Gulch or Pakoon Spring roads. The only access onto the Shivwits Plateau from the west is via the Elbow/Tombstone Canyon road to the north, or the Nutter Twists Road up Hidden Canyon. From the north, Plateau access is primarily from St. George Utah, via the Mt. Trumbull and Main Street Valley road, or the Maple/Elbow/Tombstone canyon road. From the east, access is via the Clayhole and Antelope Valley roads from Colorado City and Fredonia, respectively.

Much of the Shivwits Plateau region is roadless and rarely visited, prompting one visitor to comment that:

"Perhaps the chief value of the Lonesome Country is that in between its flashes of gaiety and enriching experience are wide mesas of stillness where the mind may rest and renew itself in the search for lost meanings and new paths. On its sheer rims or in its dreaming depths you may find a treasure, if it is treasure you seek, but it will be the riches that were hidden in yourself." (Lauritzen 1951).

GEOLOGY

Regional Structure and Stratigraphy

The Shivwits Plateau is a limestone and volcanic tableland, containing the Paleozoic strata that are exposed by the Colorado River in Grand Canyon (Billingsley 1978, Beus and Morales 1990). This Paleozoic sedimentary sequence of Grand Canyon formations extends through the Shivwits Plateau and is underlain by high grade metamorphic basement rocks that are exposed in the three crystalline inner gorges of Grand Canyon. The Paleozoic strata are downthrown nearly five km to the west of the Grand Wash Cliffs, where those strata are mixed with largely Miocene to Pliocene aged lake beds, other volcanic flows and colluvium.

The Shivwits Plateau lies between Grand Wash on the west and the Uinkaret Plateau on the east, and is structurally bounded by two major regional fault zones: the Grand Wash fault and the Hurricane fault, respectively (Huntoon 1990). A third fault, the Toroweap, forms the eastern boundary of the Uinkaret Plateau. The west-facing escarpments formed by these faults are curvilinear and essentially parallel. The areas where the escarpments bend are generally aligned to the NE, suggesting a relationship to strike-slip faults in the adjacent Basin and Range province. These three relatively young fault zones express the response of the western edge of the Colorado Plateau to Basin and Range extension. With continued extension and fault movement, they will eventually form ranges and basins, adding to the extent of the Basin and Range province. The Basin and Range/Colorado Plateau transition is a major interest among modern geologists, and is revealed in the Shivwits Plateau region in all of its considerable complexity.

Cenozoic Volcanism

The igneous caprocks and flows of the Shivwits Plateau region were first documented by John Wesley Powell (1895) during his 1869 voyage through Grand Canyon:

...a cinder cone, or extinct volcano, stands on the very brink of the canyon. What a conflict of water and fire there must have been here! Just imagine a river of molten rock running down into a river of melted snow. What a seething and boiling of the waters; what clouds of steam rolled into the heavens!

Powell's observations reflect the impressions of many who have seen the extent of volcanism in this region. The lava flows Powell referred to are extensive basaltic flows that originate from vents and small volcanoes in the Toroweap and Whitmore drainages, and across the Shivwit Plateau region (Hamblin 1990). These flows and features become progressively younger from SW to NE, indicating a gradual migration of the source volcanism. The ages of these volcanic rocks relate to the timing of downcutting of the Grand Canyon in that, for example, some of the lava flows poured into Grand Canyon, while others were cut by the Colorado River. In addition, in some places the basalt forms low cliffs that are darkly varnished by manganese-fixing bacteria and were used as petroglyph sites.

Mineral Resources

Potentially valuable minerals are rare on the Colorado Plateau, and occur in two types of settings (Billingsley *et al.* 1997). 1) Breccia pipes that form through collapse of limestone solution chambers, and containing uranium and sometimes copper and small amounts of silver, and gold. 2) small copper deposits in chert breccias within the Harrisburg Member of the Permian Kaibab Limestone. The low quantities of these minerals extracted historically indicate that they are probably of little economic importance in this region (G. Haxel, written communication). Other minerals of potential economic interest may include gypsum, sand and gravel, flagstone, cinders, gas or oil, and mineral specimens; however, the remoteness of the region and the condition of existing roads makes extraction of these commodities is an obstacle to profitable extraction.

Recent Paleontology and Climate Change

Altschul and Fairley (1989) reviewed the literature on Pleistocene/Holocene paleoenvironmental change on the southern Colorado Plateau, including the Arizona Strip. The arrival of prehistoric humans and Pleistocene-Holocene climate changes are considered the causes of the extinction of Pleistocene megafauna in this region, including elephants, camelids, Harrington's mountain goat, Shasta ground sloth, numerous large predators, and giant *Teratornis* (quasi-raptorial birds). Analyses of packrat middens, plant distribution and general atmospheric circulation models indicated that the jet stream was displaced to the south during the Wisconsin Glacial phase (prior to 12,000 years before present, ybp; Mitchell 1976, Betancourt 1984). Increased frequency of winter storms is likely to have increased winter precipitation, decreased summer precipitation and resulted in cooler summer temperatures, relative to contemporary conditions. Rapid vegetation change occurred from 12,000 ybp to 8,000 ybp, as boreal spruce, limber pine and dwarf juniper disappeared from most of the Arizona Strip plateau lands (these species presently occur above about 2,500 m elevation, but not on the Shivwits Plateau). Data from several sites on the southern Colorado Plateau indicate that ponderosa pine, gamble oak, one-seed juniper and, later, pinyon pine, arrived between 10,000 and 7,200 ybp. The present summer monsoon boundary formed during this period, although the present vegetation composition was not fully in place until 2,000 to 3,000 ybp. Geomorphic, palynological and dendrochronological data suggest that droughts were relatively common, with 10-30 yr dry periods from the early AD 200s to the early 900s, increased precipitation from the early 900s to AD 1210, a return to erratic droughts to AD 1500, generally moist conditions from AD 1500 to the mid 1800s, and a return to erratic droughts through the present. Generally, periods of higher moisture availability are associated with pulses of human agricultural activity. While the information assembled is generally applicable to the Shivwits Plateau, much remains to be learned there, and related to this general model.

BIOLOGY

Vegetation

The vegetation of the Shivwits Plateau region has been the subject of scientific investigations since prior to the turn of the Twentieth Century (Merriam 1893), and its ecotones

and vegetation processes have been the subject of additional botanical studies (e.g., Harper and Reveal 1977, Meyer 1978, Brown 1994, Moore et al. 1999). At least 232 plant species have been reported in the region thus far (Appendix 1), but 2-3 times that many species are to be expected with more detailed inventories. The region is dominated by a few, rather widely distributed vegetation types. Although it is typically sparsely vegetated, its canyon slopes and few springs often support lush riparian vegetation. Some of its plant assemblages are rare, unusual or unique and reflect long-term changes in climate and the region's unique position and biogeographic history.

Desert Vegetation: The desert in Grand Wash is dominated by creosote bush (*Larrea tridentata*), white bursage (*Ambrosia dumosa*), *Dalea* spp., and saltbush (*Atriplex* spp.). Riparian and springs are dominated by Fremont cottonwood (*Populus fremontii*), Goodding and coyote willow (*Salix gooddingii* and *S. exigua*), mesquite (*Prosopis glandulosa*), with peripheral catclaw (*Acacia greggii*) and other shrubs.

Middle Elevation Vegetation: The Sanup Plateau/Grand Wash Bench is dominated by a regionally unusual mixture of Joshua tree (*Yucca brevifolia*), blackbrush (*Coleogyne ramosissima*) and Utah juniper (*Juniperus osteosperma*; Callison and Brotherson 1985).

Chaparral-oak: South-facing slopes on the plateau's peaks and on canyon sides are covered in mixed woodland and chaparral assemblages, including New Mexican honey locust (*Robinia neomexicana*), manzanita (*Acrostaphylos pungens*), mountain mahogany (*Cercocarpus montanus*), wayleaf oak (*Quercus undulata*) and the other oaks. Desert chaparral covers only 0.5% of the plateau surface on the southwest corner of the Shivwits Plateau, but is common around the plateau margins and downslope to the Sanup Plateau.

Pinyon-Juniper Habitat: The Shivwits Plateau is primarily dominated by Utah juniper and pinyon pines (*Pinus monophylla* and *P. edulis*), which exist in vast woodlands up to elevations of approximately 2,000 m and make up more than 87% of the land coverage (Holland et al. 1979). The understory beneath pinyon-juniper stands is typically sparse, with sagebrush (*Artemisia* spp.), scrub oak (*Quercus turbinella*), which is more drought tolerant than its higher elevation counterpart, Gambels oak (*Quercus gambelii*; Neilson and Wullstein 1985).

Short-grass Prairie: The northern and eastern Shivwits Plateau region was previously dominated by grassland habitat, particularly including *Bouteloua* spp. However, overgrazing has apparently removed much of the grass cover and allowed woody and succulent shrubs to invade, including snakeweed, banana yucca (*Yucca baccata*) and various cacti (Dutton 1882, Hoffmeister and Durham 1971). This habitat type is transitional to pinyon-juniper woodland.

Sagebrush: Large stands of bigtooth sagebrush (*Artemisia tridentata*) occur in natural and chained open areas on the Shivwits Plateau. Snakeweed (*Gutierrezia sarothrae*) is abundant, particularly on grazing-disturbed uplands, and rabbitbrush (*Chrysothamnus nauseosus*) is also common, particularly around artificial ponds. Great Basin sagebrush desertscrub makes up 3.6 percent of the

landscape and plains grassland makes up approximately 5.8 percent, but the latter cover type has been highly degraded by grazing (Holland et al. 1979).

Ponderosa Pine: Ponderosa pine (*Pinus ponderosa*) occurs at higher elevations, and makes up 2.7 percent of the plateau. Ponderosa pine often occurs as riparian “stringers” in the small drainages that flow from the plateaus higher peaks. This means that water courses in the upper elevation pinyon pine/juniper habitats are marked by long narrow stands of ponderosa pines. The understory beneath ponderosa pine here includes a typically sparse mixed shrub assemblage, with Gambels oak, sagebrush (*Artemisia* spp.), mountain mahogany, and various grasses. Ponderosa pine has been in the region since approximately 10,400 yr (Moore et al. 1999).

Riparian Vegetation: The general absence of water precludes development of much deciduous or riparian vegetation at higher elevations in this region; however, some canyons and those few springs that are not entirely boxed allow some phreatophytic growth. For example, Green Springs Canyon lies 6 km ESE of Mt. Dellenbaugh and supports upland slopes of Gambel’s oak (*Quercus gambelii*), and a limited stand of riparian vegetation (Blake 1981). Springs and riparian areas in the Shivwits Plateau region of special concern to the Bureau of Land Management (1990) include those listed in Table 1. Some, such as Grapevine Spring, have been closed to grazing, and host profuse stands of Fremont cottonwood and other native phreatophyte trees. However, many springs have been developed and their water diverted for livestock or human consumption.

The few springs in this region that have been studied are often found to support rare, endangered, endemic or other species of special concern, but floristic surveys of Shivwits region springs have not been conducted. One large Arizona Strip spring in Grand Canyon that has been relatively thoroughly studied is Vasey’s Paradise (Colorado River Mile 31.5L, mean discharge = 33 L/s, 0.2 ha of riparian habitat; Stevens unpublished data). In addition to rare, isolated populations of heleborine orchids (*Epipactis gigantea*), it displays cardinal flower (*Lobelia cardinalis*) and poison ivy (*Toxicodendron rydbergii*; Clover and Jotter 1944). Springs on the south side of Shivwits Plateau in Grand Canyon support populations of endemic McDougalls flaveria (Asteraceae: *Flaveria mcdougallii*).

Table 1: Springs areas of special concern to the BLM (1990), and others from the Shivwits region.

NAME	TNSHP,RANGE
Bitter Seep Wash	T39N, R4W
Sullivan Spring	T39N,R14W
Gates-Mullen Spring	T39N, R14W
Buckhorn Spring	T34N R16W
Grapevine Spring	T34N R16W
Whiskey Spring	T34N R16W
Little Arizona Spring	T34N R16W
Cottonwood Spring	T42N R6W
Red Rock Spring	T36N R16W
Middle Spring	T36N R16W

Cane Spring	T38N R14W
Pocum Wash	T38N R14W
Elbow Canyon Complex	T39N R15W
Kelly Dam	T32N R12W

Some information also is available on Tassi Spring on LMNRA in Grand Wash. This spring is dominated by Fremont cottonwood, Goodding willow (*Salix gooddingii*), catclaw and seepwillow (*Baccharis* spp.). In a remarkable control effort, the National Park Service has entirely removed saltcedar (*Tamarix ramosissima*) from this site, as well as from Burro Spring, which is approximately 20 km farther upstream on Grand Wash. Tassi Spring is floristically similar to Grapevine Spring and a series of other springs that emerge from the base of the Sanup Plateau, and all are biological hotspots, supporting the only area populations of numerous neotropical migrant song bird species, as well as various woodpeckers, Gambel quail (*Callipepla gambelii*) and endemic Grand Wash spring snail (Hydrobiidae: *Pyrgulopsis bacchus*). Improved information on the distribution of native and non-native species at springs is needed to help land owners improve management strategies for these rare, biologically productive sites.

Invertebrates

Little is presently known regarding the invertebrates of the Shivwits Plateau and surrounding region. Waltz (1998) recorded 31 species of butterflies and skippers in 5 families on Mt. Trumbull. Invertebrates exerting dominant influences on the landscape include harvester ants (*Pogonomyrmex rugosus*, *P. californicus* and other spp.) in pinyon juniper, grassland and desert habitats, where these ant species extensively rework the soil and alter herb and shrub cover. Tenebrionid beetles are likely to be important decomposers of vegetation in those habitats as well, and various Orthoptera are likely to be important herbivores.

Studies in this region indicate that springs are particularly likely to support endemic invertebrate species. Again using the one biologically well-studied Arizona Strip spring in Grand Canyon as an example, Vaseys Paradise supports at least four endemic invertebrate species, including a chironomid midge (*Metriocnemus stevensi*, Sublette et al. 1997), an as yet undescribed empidid fly, endangered Kanab ambersnail (Succineidae: *Oxyloma haydeni kanabensis*; Spamer and Bogan 1993), and another, as yet undescribed succineid landsnail in the genus *Catinella* (S.K. Wu, personal comm.). The Grand Wash spring snail found at Tassi Spring is known from other low elevation springs on the west side of the Sanup Plateau (Grapevine, Whiskey, and probably other springs in Grand Wash that are on private land; Hershler and Landye 1988). Other endemic invertebrates are likely at these sites, but thorough inventories have not been conducted (Kent Turner, LMNRA, personal communication). The Grand Canyon Wildlands Council has received support from the Arizona Water Protection Fund to inventory the invertebrates of Arizona Strip springs in 2000-2001, and this inventory will greatly augment information on the distribution of springs plant, invertebrate, and vertebrate species.

Fish

Native fish do not occur on the Shivwits Plateau, as far as is presently known. The Virgin River to the north supports dwindling populations of native fish, including speckled dace (*Rhinichthys*

osculus), Virgin River spinedace (*Lepidomeda m. mollispinis*), woundfin (*Plagopterus argentissimus*), flannelmouth sucker (*Catostomus latipinnis*), round-tailed chub (*Gila robusta seminuda*) and Gila mountain-sucker (*Pantosteus clarki*; Minckley 1973). Speckled dace, humpback chub (*Gila cypha*), flannelmouth sucker and bluehead sucker (*Catostomus discobolus*) populations remain in the Colorado River in Grand Canyon and its tributaries. These tributaries may be influenced by overgrazing (increased sediment yield), fire, urbanization (including ground water extraction), and other land use practices in the Shivwits Plateau region. Native bonytail chub (*Gila elegans*), Colorado pikeminnow (*Ptychocheilus lucius*), and razorback sucker (*Xyrauchen texanus*) have been largely or completely extirpated from the Colorado River in Grand Canyon and Lake Mead, and more than 20 non-native fish species have been released into those waters. Stevens (personal communication) observed a small population of speckled dace and non-native goldfish at Tassi Springs in Grand Wash in August 1999, which may be the only native fish population in the study area.

Herpetofauna

The amphibians and reptiles of the Shivwits Plateau are known primarily from the few data compiled by LMNRA and BLM staff and researchers. Recent possible declines in desert tortoise (*Gopherus agassizi*) populations have become an important conservation concern for the U.S. Bureau of Land Management on the western Arizona Strip (Dickinson et al. 1995), and a large conservation program is underway along the northwestern side of the Shivwits Plateau. In addition, six other herpetofaunal species are of concern to the state of Arizona and the BLM on and around the Shivwits Plateau. However, detailed range maps of the Shivwits' herpetofauna are not available, and additional data are needed for a realistic assessment of species distribution and population status.

Avifauna

We found evidence of at least 116 bird species on and around the Shivwits Plateau, an assemblage that is large, but not unusual for this region. Blake (1981) detected a total of 92 bird species on and around Mt. Dellenbaugh during surveys in 1974-1975, of which 56 species occurred year-round, and 36 species as migrant or accidental. His data are combined with those from the few other regional avifaunal studies (Huey 1939, Rasmussen 1941, Behle 1943, Behle et al. 1958, Wauer and Carter 1965, 1967, Arizona Breeding Bird Atlas unpublished, and our own observations in the summer of 1999; Appendix 2). Additional data on the ponderosa pine forest avifauna are being gathered by W. Covington's Northern Arizona University research team, and will be available shortly. Recently, the Arizona Game and Fish Department collected avifaunal data on randomly chosen survey and priority blocks, as well as observations made off those sites in the vicinity of Mt. Trumbull, Poverty Spring, and Mustang Point (Arizona Breeding Bird Atlas unpublished data, 1993-1998).

Springs off the western edge of the Sanup Plateau, such as Tassi, Grapevine and Whiskey springs, support profuse stands of riparian Fremont cottonwood, mesquite and catclaw, and our observations in July and August 1999 revealed numerous neotropical migrant bird species associated with those habitats (Appendix 2). Of some relevance to the ecotonal nature of the Shivwits/Sanup region is the co-occurrence of both blue-gray and black-tailed gnatcatchers

(*Poliophtila caerulea* and *P. melaneura*, respectively). Also of regional interest is the release of nine endangered California condors (*Gymnogyps californianus*) by the U.S. Fish and Wildlife Service from a site on the Hurricane Cliffs in 1998, and an additional nine birds in 1999.

A previously unexplored biological issue is the possible use of the Shivwits Plateau's two major north-trending escarpments as a migratory raptor pathway. A large number of raptors migrate through southern Nevada (Herron et al. 1985) and springtime hawk movement up the Hurricane Fault system has been observed (C. LaRue, personal communication). Migrating raptors commonly use upwardly-rising air currents that develop as mountain valley winds along escarpments, such as the Grand Wash and Hurricane cliff lines. We tested this hypothesis by conducting an aerial reconnaissance of the Grand Wash and Hurricane cliffs on 1 October 1999. Three observers flew in a Cessna along the Grand Wash from Snap Point to Last Chance Knoll (two passes), and along the Hurricane cliffs (one pass), with each pass lasting approximately 20 minutes. The mid-late morning weather was warm and with a very slight breeze and reasonable updrafts along the cliffs, and we flew at a speed of approximately 115 km/hr. We tentatively identified accipiters (probably Cooper's hawk, *Accipiter cooperi*), golden eagle (*Aquila chrysaetos*), other buteonids, turkey vulture (*Cathartes aura*, not along cliffs) and common ravens (*Corvus s. corax*) on these surveys. The average detection rates of all species was 0.1 (1 sd = 0.03) raptors/km and 9 (1 sd = 3.0) birds/hr. While these values are not exceptional, the data indicate use of these cliff lines by raptors. More thorough surveys would provide better resolution of the extent, timing and daily variability of migratory raptor use of these prominent escarpments. It was of interest that we did not detect much "whitewash" on this brief reconnaissance, suggesting that raptors may not extensively use these cliff lines for nesting, perhaps because of the hot, western exposure.

Mammals

Small Mammals: Like most other faunal groups, the mammals of the Shivwits Plateau region are known from only a few scientific studies. Hoffmeister and Durham (1971) and Hoffmeister (1986) listed the mammal species, and distribution and biogeographic anomalies in the region (Appendix 3). Their data indicate that at least 49 mammal species occur on the Shivwits Plateau, and many more occur around the periphery, particularly along the transition boundary with the Sanup and Grand Wash to the west. Hoffmeister and Durham (1971) concluded that the common mammals of the creosote bush-saltbush vegetation type (i.e., in the Grand Wash area) included 8 species: *Perognathus longimembris*, *Perognathus penicillatus*, *Dipodomys microps*, *Dipodomys merriami*, *Dipodomys deserti*, *Peromyscus eremicus*, *Onychomys torridus*, and *Vulpes macrotis*. In addition, low elevation mesquite-saltbush riparian areas may support *Procyon lotor*. We observed many of these species during a visit to that region in July/August 1999. In Joshua tree habitat on the Sanup Plateau/Grand Wash Bench, Hoffmeister and Durham (1971) reported *Lepus californicus*, *Dipodomys micros*, and *Peromyscus eremicus*. In chaparral-oak habitats at higher elevations around the rims of the Shivwits Plateau and in canyon environments, they reported *Eutamias dorsalis* and *Peromyscus boylii*. Great Basin sagebrush habitat support *Sylvilagus audubonii*, *Lepus californicus*, *Perognathus longimembris*, and *Dipodomys ordii*, while short grass prairie on the northern Shivwits Plateau support *Perognathus parvus*, *Onychomys leucogaster*, and a few rare *Antilocapra americanus*. Pinyon –Juniper habitat supports *Lepus californicus*, *Eutamias dorsalis*, *Peromyscus boylii*, *Peromyscus truei*, *Lynx rufus* and *Odocoileus hemionu*. Ponderosa pine habitat supports

Tamias dorsalis, *Peromyscus boylii*, *Peromyscus maniculatus*, *Erethizon dorsatum*, and *Odocoileus hemionus*. Waltz (1998) reported capturing 3 species in 5600 trap nights, an assemblage strongly dominated by *Peromyscus maniculatus* (135 individuals), followed by *P. truei* (74 individuals), *P. boylii* (61 individuals) and *Tamias dorsalis* (14 individuals). Blood sampling revealed that Hantavirus infection ranged from 4.7% to 17.3% among the *Peromyscus* species, but was not present in *Tamias dorsalis* chipmunks.

Predators: Large predators are relatively rare in this region, and typically are restricted to coniferous woodlands and forests, and escarpment edges. At least one record of a gray wolf (*Canis lupus*) has been reported from Mt. Trumbull area (P. Sneed, personal communication), and mountain lion (*Puma concolor*) have been reported from that vicinity as well (e.g., Cox and Russell 1973). Black bear (*Ursus americanus*) are rare or non-existent on the Shivwits Plateau. Coyote (*Canis latrans*) and bobcat (*Felis rufus*) are more widely distributed across the Shivwits Plateau region than are larger predators. The smaller predators and golden eagles are more likely to occur in the broken country along escarpment edges.

Desert Mule Deer: Ungulate populations have been of enduring subsistence and economic interest to residents and game managers (AGFD) of the Shivwits Plateau region. Desert mule deer (*Odocoileus hemionus*) can grow to be exceptionally large on the Shivwits Plateau. Lack of summer water probably prevents desert mule deer from remaining on the southern Shivwits points during the summer; however, Kaibab mule deer use snow as a water source during the winter, following it downslope as it falls and upslope as it melts. Bostick (1988b) observed two cycles of deer population growth on the southern Shivwits, which occurred in the presence of continuous livestock grazing. The Kaibab deer population increased in the 1940's and crashed in the 1950's, and increased again in the 1960's. Therefore, including the mule deer population rise and crash recorded by Rasmussen (1941), at least three population cycles of desert mule deer have occurred in the region during this century. The primary forage for mule deer on southern Shivwits Plateau points and canyons is cliff rose, which is closely cropped throughout the year. Bostick (1988b) concluded that high deer population levels about 35 ± 10 yr (prior to 1988) caused a die-off of cliff-rose and sagebrush on the Parashant grazing allotment.

Pronghorn: The pronghorn population had declined on the northern half of the Shivwits Plateau in the latter half of this century, but the pronghorn (*Antilocapra americana*) population has been augmented over the past decade by the AGFD. Pronghorn numbered 150-200 head by 1998. Pronghorn occurred on the Shivwits Plateau and surrounding region until at least 1916 (Knipe 1944, Cox and Russell 1973). The pronghorn present in AGFD Unit 13 (Arizona Strip west of Kanab Cr.) are reintroduced, and result from three transplant efforts (AGFD 1978). The first was in 1961 and involved moving 34 animals from Anderson Mesa, but "the results were not encouraging (AGFD 1978:35). In 1965 55 Montana pronghorn were released, but the success of the release was not apparent until 1974, when 11 animals were spotted during aerial surveys. That number had increased to 81 animals by 1977. The largest population presently occurs in Antelope Valley, north of Mt. Trumbull, from Larimore Tank on the south to Upper Clayhole Valley on the north, and from June Tank on the east to Temple Trail Tank. Another population

was transplanted between Cunningham Canyon and the NPS boundary in Toroweap Valley, but it was not expected to persist.

Pronghorn occur across western US, with ranges from 65 km² to 250 km² (Yoakum 1980). Pronghorn mostly range from 900 to 1800 m elevation, but move higher (to 2700 m) in summer in the Southwest. Arizona pronghorn make much more use of woodland and forest habitat than expected, but their use of these habitats is not well known. Pronghorn require 1.5 to 0.75 kg of forage/day (dry mass) and up to 1 kg/d on the range (Severson and May 1967, Schwartz and Nagy 1976), and their diet is opportunistic and selective, taking browse year-round, with forbs dominant in spring and summer, and grasses used only in early growth periods (Autenreith 1978, Allen et al. 1984). The success of the pronghorn restoration program has allowed the AGFD to issue hunting permits during the past two decades.

Desert Bighorn Sheep: Like pronghorn, desert bighorn sheep (*Ovis canadensis nelsoni*) were essentially extirpated from the Arizona Strip by the early 1900's, except in lower Kanab Creek and along the southern Grand Wash Cliffs. Bighorn sheep populations are believed to have been more abundant and more widely distributed historically. These animals are highly valued by the public for wildlife viewing, photography, and hunting opportunities. Since the late 1970's, the BLM and the AGFD have been cooperatively working to re-introduce desert bighorn sheep onto the northwestern Shivwits Plateau region, re-introduction efforts which have been successful (U.S. Bureau of Land Management 1997). As of 1996, apparently stable populations of desert bighorn occupied the Virgin and Beaver Dam Mountains and the Grand Wash Cliffs, and the total population on the Arizona Strip numbered approximately 550 animals on BLM administered lands. Augmented water sources (guzzlers) have helped with these population enhancement efforts, and additional bighorn sheep releases are on-going.

Species of Special Concern

The Shivwits region supports at least 232 plant species, only one known fish population (at Tassi Spring), numerous but poorly documented amphibian and reptile species, 116 bird species, and 49 mammal species (Appendices). Of this total, as many as 59 (15%) are recognized as rare and sensitive species of concern to the State of Arizona, the U.S. Fish and Wildlife Service, and other federal agencies. Species of concern that do or may occur in the region include: 32 plant species, 1 mollusc, 1 arthropod, 3 amphibians, 4 reptiles, 10 bird species (of which 7 are likely to be present only during migration), and 5 mammal species (Table 2).

Table 2: Species of concern that do or may occur in the proposed Shivwits National Monument area. "Grank" applies to global status, "Srank" applies to Arizona State status. Data sources include Bureau of Land Management (1992) and Arizona Heritage data (courtesy of Arizona Game and Fish Department).

Common Name	Scientific name	G RANK	S RANK	SOURCE
Plants				
Aravaipa Wood Fern	<i>Thelypteris puberula</i> var <i>sonorensis</i>	G4T4	S1	AZ Heritage
Atwood Wild-Buckwheat	<i>Eriogonum thompsonae</i> var <i>atwoodii</i>	G2	S2	AZ Heritage
Blackrock Ground Daisy	<i>Townsendia smithii</i>	G5T3T4	S2	AZ Heritage
Blue Curls	<i>Trichostema micranthum</i>			BLM
Bunch Flower Evening-Primrose	<i>Camissonia confertiflora</i>	G2	S2	AZ Heritage
Darrow's Buckwheat	<i>Eriogonum darrovii</i>	G2	S1	AZ Heritage
Fickeisen Pincushion Cactus	<i>Pediocactus peeblesianus</i> var <i>fickeiseniae</i>	G3	S3	AZ Heritage
Fredonia Catseye	<i>Cryptantha semiglabra</i>	G2	S1	AZ Heritage
Grand Canyon Rose	<i>Rosa stellata</i> ssp <i>abyssa</i>	G4QT3	S3	AZ Heritage
Gumbo Milk-Vetch	<i>Astragalus ampullarius</i>	G1	S1	AZ Heritage
Holmgren Milk-Vetch	<i>Astragalus holmgreniorum</i>	G1	S1	AZ Heritage
Hopi Sunflower	<i>Helianthus anomalus</i>	G2G3Q	S2	AZ Heritage
Juniper Buttercup	<i>Ranunculus juniperinus</i>			BLM
Kaibab Sedge	<i>Carex scirpoidea</i> var <i>curatorum</i>	G2	S2	AZ Heritage
Kearney Mustard	<i>Thelypodopsis purpusii</i>	G4T2	S2	AZ Heritage
King Clover	<i>Trifolium kingii</i> ssp <i>macilentum</i>	G5TUQ	SU	AZ Heritage
King Snapdragon	<i>Antirrhinum kingii</i>			AZ Heritage
Least Evening Primrose	<i>Camissonia parvula</i>			BLM
Longspine Cotton Thorn	<i>Tetradymia axillaries</i> var <i>longispina</i>	G4T2	S2	AZ Heritage
Marston Beehive Cactus	<i>Coryphantha missouriensis</i> var <i>marstonii</i>	G2	S2	AZ Heritage
Mt. Trumbull Beardtongue	<i>Penstemon distans</i>	G3G4Q	S1	AZ Heritage
Navajo Mountain Phlox	<i>Phlox cluteana</i>	G4?	S2	AZ Heritage
Nevada Bluegrass	<i>Poa nevadensis</i>			BLM
Nevada Moonpod	<i>Selinocarpus nevadensis</i>			BLM
Scarlet Wild-Buckwheat	<i>Eriogonum zionis</i> var <i>coccineum</i>	G2	S2	AZ Heritage
Sheep Range Beardtongue	<i>Penstemon petiolatus</i>	G3T3	S1	AZ Heritage
Shrub Gilia	<i>Ipomopsis frutescens</i>	G2T2	S2	AZ Heritage
Siler Pincushion Cactus	<i>Pediocactus sileri</i>	G3	S2	AZ Heritage
Tawny Turpentine Bush	<i>Haplopappus cervinus</i>	G2G3	S1	AZ Heritage
Two-Leaf Bedstraw	<i>Galium bifolium</i>			BLM
Virgin Narrows Spike Moss	<i>Selaginella leucobryoides</i>	G4T2	S1	AZ Heritage
Watson Spike Moss	<i>Selaginella watsoni</i>			BLM
	<i>Heuchera rubescens</i>			BLM
Arthropoda				
Grand Canyon Cave Pseudoscorpion	<i>Archeolarca cavicola</i>			BLM
Mollusca				
Desert Springsnail	<i>Pyrgulopsis deserta</i>	G2	S1	AZ Heritage
Grand Wash Sprinsnail	<i>Pyrgulopsis bacchus</i>	G2	S1	Hershler and Landey 1988

Herpetofauna				
Arizona Toad	<i>Bufo microscaphus microscaphus</i>	G4T3T4	S3S4	AZ Heritage
Chuckwalla	<i>Sauromalus obesus obesus</i>			
Desert Tortoise	<i>Gopherus agassizii</i>			BLM
Northern Leopard Frog	<i>Rana pipiens</i>			BLM
Relict Leopard Frog	<i>Rana onca</i>			BLM
Utah Milk Snake	<i>Lampropeltis triangulum taylori</i>			BLM
Utah Mountain Kingsnake	<i>Lampropeltis pyromelana infralabialis</i>			BLM
Avifauna				
American Bittern	<i>Botaurus lentiginosus</i>			BLM
Bald Eagle	<i>Haliaeetus leucocephalus</i>			BLM
Belted Kingfisher	<i>Megaceryle alcyon</i>			BLM
Common Black Hawk	<i>Buteogallus anthracinus</i>			BLM
Ferruginous Hawk	<i>Buteo regalis</i>			BLM
Mexican Spotted Owl	<i>Strix occidentalis lucida</i>	G3T3	S3S4	BLM
Northern Goshawk	<i>Accipiter gentilis</i>			BLM
Peregrine Falcon	<i>Falco peregrinus anatum</i>			BLM
Snowy Egret	<i>Egretta thula</i>			BLM
Southwestern Willow Flycatcher	<i>Empidonax trailii extimus</i>			BLM
Mammals				
California Leaf-Nosed Bat	<i>Macrotus californicus</i>			BLM
Greater Western Mastiff Bat	<i>Eumops perotis californicus</i>	G5T4	S1S2	AZ Heritage
Merriam Kangaroo Rat	<i>Dipodomys merriami frenatus</i>			BLM
Red Bat	<i>Lasiurus borealis</i>			BLM
Spotted Bat	<i>Euderma maculata</i>			BLM

Shivwits Plateau Area Ecosystems

Kelly Point: Bostick (1988a, b) provided first-hand accounts of the condition of two grazing allotments on the southern Shivwits Plateau. Kelly Point is the longest peninsula extending south from the Shivwits Plateau. From the LMNRA boundary, Kelly Point extends out into the Grand Canyon for 40 km, and comprises the Home Range Grazing Allotment. It is covered with basalt, and the point is at 1,847 m, rising to the north to 1920 m. Yellow John Mountain (2,042 m) is a volcanic dome rising 150 m above the plateau.

Bostick (1988a) concluded that the pristine condition of Kelly Point was a woodland savannah, with pinyon pine associated with mutton-grass (*Poa fendleriana*) and juniper associated with black grama (*Bouteloua eriopoda*), and stands of park-like ponderosa pine. Today, Kelly Point is dominated by pinyon pine-Utah juniper woodland, with some ponderosa pine forest. The pinyon juniper forest has old growth, with enormous Juniperous osteosperma, which Bostick (1988a) guessed to be one thousand years old, >15 m tall, and >1.1 m in diameter at breast height. The ponderosa pine forest has old growth, with trees 300-400 yr in age. Dominant shrubs include rubber weed (*Hymenoxys cooperi*), *Hymenopappus lugens*, and scurf pea (*Psorelea tenuiflora*).

Kelly Point has been strongly affected by human activities. The point was logged 60 and 110 years ago, and ponderosa pine doghair thickets are now abundant. The range condition is similarly altered, but is not all in poor condition. The range around Green Spring is in "fair condition", and

range conditions improve to the south, past Shanley Tanks. Bostick (1988a) considered the needle and thread grass (*Stipa comata*) stands were recovering somewhat from intensive overgrazing.

Bostick (1988a) described range conditions in Pleasant Valley and Horse Valley, and the smaller Horse Valley north of Green Spring. Grazing around the cattle tanks there usually resulted in bare ground; however, moist areas around the Pleasant Valley tank were occupied by *Polygonum aviculare* and cheat grass (*Bromus tectorum*). The margins of Pleasant Valley supported mat muhly (*Muhlenbergia richardsonia*) and blue grama (*Bouteloua gracilis*). *Agropyron smithii* and *Sitanion hystrix* grasses occurred at the north end of that valley. The northwest end of the valley supported 25 m-tall Gambels oak that were 0.7 m in diameter, and may be a size record for that species.

Horse Valley is the largest meadow on Kelly Point, with permanent water, a ranch headquarters, and corrals. Bigtooth sage surrounded the valley, but the meadow was free of shrubs, and was dominated by sedge (*Carex nr obtusata*), with considerable annual *Bouteloua simplex* grass. Bostick (1988a) speculated that the sedge meadow resulted from intensive grazing that eliminated shrubs, with 1,728 to 2,970 AUM since 1981.

The Parashant Grazing Allotment: The Parashant/Andrus drainage system is a large Colorado River tributary that dissects the southern Shivwits Plateau. Bostick (1988b) reviewed ecological and range conditions of the Parashaunt Grazing Allotment, which includes two large, southward projecting peninsulas: Burnt Canyon and Twin Canyon points. Burnt Canyon Point is a relatively short, broad point, on the west side of Burnt Canyon, while Twin Point is a long, narrow point on the east side of Burnt Canyon. Both of these points lie at an elevation of 1,830 m. The Esplanade platform below the rim is accessible from at least 4 trails, and is occupied by blackbrush (*Coleogyne ramosissima*). Small tinajas occur there, which may provide natural water sources for wildlife.

Utah juniper and pinyon pine are codominant on the plateaus, and bigtooth sage and other sage species occupy the valleys. Twin Point supports populations of banana yucca (*Yucca baccata*), and several grasses (i.e., *Poa fendleriana* and *Sitanion hystrix*), pine beardtongue (*Penstemon linarioides*), Mormon tea (*Ephedra nevadensis*), snakeweed (*Gutierrezia sarothrae*), and cliffrose (*Cowania mexicana* var. *stansburyana*). This latter species is an important forage species for deer. Just within LMNRA boundary, cliff rose, bigtooth sagebrush and blue gramma grass are common. Just outside the boundary on BLM land snakeweed, a disturbed ground species, became more common, and the rangeland was denuded, with bare ground common and low-growing scurf pea and birdsbeak (*Cordylanthus parviflorus*) the only shrubs. Recovery of the range was apparent near the end of the point, with grasses becoming more common, and *Penstemon pachyphyllus* var *congestus* was recolonizing bare soils in some areas.

These points have changed dramatically over the past century, as intensive grazing has altered ground cover and understory composition. Younger trees have filled in canopy gaps in the pinyon-juniper woodland, and the canopy has become closed. Bostick (1988b) estimated that the grazing involved 2,290 to 3,708 AUMs, and the region was used for winter grazing. However, all domestic livestock were removed from the LMNRA lands there in 1988.

Rosa stellata exists in a rare population on Twin Point in a highly disjunct 2.5 ha habitat containing about 32,000 plants. This species is found in west Texas, southern New Mexico, and northern Mexico, and this stand is one of very few in the Grand Canyon region. The Twin Point road passes through the stand.

Springs Ecosystems: The springs of the Shivwits Plateau are among its most significant features. These springs are known from historical accounts and from a large, unpublished synoptic study by the Bureau of Land Management in 1987. The BLM study included information on discharge, vegetation, and human use of 34 springs on the southern Shivwits Plateau, of which more than 75% have been largely or completely developed for human use and livestock watering. No data were available on the additional nine springs mapped in this area. In addition, there are at least 24 springs known in Grand Canyon National Park immediately to the south of the BLM- and LMNRA-administered Shivwits Plateau, of which few have been developed. This brings the total number of springs on the southern half of the Shivwits Plateau to at least 67, not counting three “wells” that originally may have been seeps that have been mined for water. The biota of Shivwits springs has not been studied. Some of the springs in Grand Canyon National Park, on the north side of the Colorado River are likely to have hydrologic connections to aquifers within the Shivwits Plateau. Management concerns exist over grazing and the invasion of non-native plant species at the region’s springs because these habitats are fragile and particularly susceptible to such invasion (Stevens and Ayers in press). The National Park Service at LMNRA has successfully removed non-native tamarisk from several low elevation springs, and the BLM is conducting similar efforts at low elevation springs as well. Both agencies have fenced off springs in Grand Wash from livestock grazing.

Mt. Trumbull: The Mt. Trumbull Resource Conservation Area (RCA) is a ponderosa pine forest on which fire suppression, grazing and logging have altered forest structure and composition. The pre-Euro-American fire frequency was 3-5 yr, but fire suppression has allowed fuel loads to accumulate, threatening this ecosystem with potentially devastating fires. Although this appears to be the normal condition for ponderosa pine forests throughout the Southwest, the Mt. Trumbull RCA is unique in that it has been selected as a site in which to scientifically test forest restoration options in an interagency effort spearheaded by W.W. Covington and his associates at Northern Arizona University (Waltz 1998, Moore et al. 1999). This multi-disciplinary project promises to clarify how to improve management of ponderosa pine and other forest ecosystems.

HUMAN HISTORY

Prehistoric Humans

Archeological Research: Current knowledge about the archeology of the region north of Grand Canyon and west of Kanab Creek comes from a series of investigations conducted primarily for various land management agencies during the past eight decades. Most of the investigations have involved reconnaissance level surveys of large parcels of land, rather than in-depth studies of particular localities. Less than 1% of the Shivwits Plateau region has been surveyed for cultural sites, and consequently much of the current knowledge is general and superficial, rather than detailed and specific.

Archeological and anthropological research in the Shivwits Plateau region has revealed the presence of several prehistoric Native American cultures, including hunter-gatherer Paleoindians (ca. 8,000 BC prior to 300 BC), Formative (Basketmaker II through Pueblo III periods, 300 BC

to AD 1250) Anasazi, and the Neo-archaic period (Shoshonean Paiute Indians, after AD 1200; Fairley 1989). Early studies indicated that the Shivwits Plateau region was used by hunting and gathering Paleoindians. A fragment of a Paleoindian Clovis point was collected during Miller's (1978) survey of Sullivan Canyon, indicating the long time frame of human presence in the region (Lipe and Thompson 1979). The region formed the northwestern frontier of the Anasazi culture. Remains from the Formative periods are distinct from the Kayenta Anasazi of the Four Corners area, and are described as Virgin River Anasazi. In late prehistoric and historic times, the region has supported small hunting and gathering groups of Southern Paiute Indians, and one Southern Paiute Indian reservation presently exists on the Arizona Strip.

Several studies provided important insights into the distribution and life style of Desert Archaic, Virgin River Basketmaker and Puebloan Indians, and modern Paiute Indians. The earliest archeological information on the region was Jedidiah Smith's report in 1826 of extensive prehistoric salt mines near the confluence of the Virgin and Muddy rivers, which were inundated by Lake Mead (Morgan 1953). Powell and Ingalls (1874) reported on the condition of Shivwits Plateau Indians, initiating interest in the extent of prehistoric humans and contemporary presence there. Archeological exploration, excavations and surveys were conducted on and around the Shivwits Plateau by Edward Palmer from 1870-1876 (Fowler and Matley 1978), the Smithsonian Museum from 1915-1919 (Judd 1921, 1926), Harrington (Shutler 1961), Wheeler (1942), Schenk (1937), and Aikens (1966). G. Baldwin conducted a reconnaissance survey of Whitmore Canyon and elsewhere on the Shivwits Plateau in the 1940s, and around Lake Mead in the late 1940s and early 1950s. On the Shivwits, he reported sites that were mostly artifact scatters, but a few multi-room dwellings (Baldwin 1978). R.C. Euler and M. Wetherill excavated Antelope Cave on the Uinkaret Plateau in 1954, finding evidence of Basketmaker III to Pueblo II period occupation (Johnson and Pendergast 1960).

Reconnaissance-level archeological surveys were conducted on the southern Shivwits, Uinkaret, and Kanab Plateaus by archeologists working for the Smithsonian Institution (Judd 1919, 1926), the National Park Service (Baldwin 1942, 1950; Teague and McClellan 1978; Wells 1991) and the Bureau of Land Management (Lipe and Thompson 1979; Moffitt and Chang 1978). These studies were undertaken for both basic research and general land management planning needs. Two localized studies also were conducted in some of these same areas in response to proposed uranium mine developments (Holmer 1977, Westfall 1987). In addition, the U.S. Forest Service has undertaken occasional small-scale inventory surveys in the Kanab Wilderness. Together, these investigations provide a general understanding of the types, density, and diversity of archeological resources on federal lands in northwestern Arizona north of Grand Canyon National Park.

Archeologists and anthropologists on the Arizona Strip diverged in their opinions about the diversity and density of cultural resources in the area. This variety of opinions reflects the fact that few researchers have focused their careers on studying this remote region, and for many of them, their knowledge has been limited to observations made in the course of a single project. Investigations that focused on open grasslands and sage-covered valley bottoms tended to find few sites of a very limited nature (*e.g.* Moffitt et al. 1978), while those that focused on the wooded ridge tops and mountain slopes (Westfall 1987; Moffitt and Chang 1978) or specifically explored the overhangs and spring locales along the Esplanade (Huffman 1993) typically

encountered more diverse and complex remains. Thus, depending on where they worked and the methods they employed, researchers typically reported on only a subset of the total spectrum of archeological resources present in the area.

Thompson and Thompson (1974, 1978) conducted an archeological reconnaissance of Toroweap Valley in the 1960s and 1970s, reporting 351 sites, primarily dating to Pueblo I and II but including sites dating to AD 1400. The Navajo-McCullough powerline transmission line survey revealed extensive Desert Archaic occupation of the northern Arizona Strip (Moffitt et al. 1978). Moffitt and Chang (1978) reported 80 archeological sites on 2,087 acres of Mt. Trumbull, including 10 large C-shaped pueblos, 28 smaller pueblos, 17 fieldhouses, 12 artifact scatters, 1 check dam, 1 storage structure, 2 trails and 2 roasting pits dating to the Pueblo II-III periods. In addition, their survey revealed 8 historic sites related to lumber mills and camps. Miller (1978) reported 34 sites in Sullivan Canyon (just off the northwest corner of the Shivwits Plateau), including lithic tool sites, rock shelter dwellings, campsites, and roasting pits.

Some of the archeological surveys initiated in the 1970s for planning purposes employed a sampling strategy in which randomly selected areas were examined in detail and the results were subsequently extrapolated to the region as a whole. Regrettably, some of these early sample surveys were inadequately designed and insufficient in size, leading to erroneous conclusions about the density and diversity of archeological resources in the sampled area. The most blatant example of this was the sample survey conducted as part of the Grand Canyon Adjacent Lands Study in 1977 (Teague and McClellan 1978). This survey was originally intended to examine at least 2% of 730 square miles, divided in two blocks between the southern Kanab and Shivwits Plateaus; however, less than 0.5% of the targeted area was actually examined. This survey documented 43 quarries, campsites and chipping areas dating to the Archaic period (ca. 2500 BC-AD 1), Puebloan period (ca. AD500-1150) and Southern Paiute occupation (ca. AD1250-1880). They also located pictograph sites and one granary, plus several historic period ranches and mines; however, they failed to locate a single permanent habitation site on the Kanab Plateau, and only a few small early pueblo sites were found on the Shivwits Plateau.

Based on their data, Teague and McClellan (1978:179-180) and the National Park Service (1981:28) concluded that the region was marginal for horticulture and that farming was never an important activity in this area. Furthermore, Teague and McClellan (1978:178) concluded that land encompassed within the Adjacent Lands Study Area was only seasonally or sporadically used by peoples whose main habitation areas lay elsewhere and that the Esplanade bench below the plateau rim contained relatively few archeological resources compared with the plateau uplands. In addition, they concluded that the projection of site densities based on the sample survey (which indicated that there were probably tens of thousands unrecorded sites in the study area) was unreasonably high. In retrospect, all of these conclusions were incorrect.

Subsequent studies conducted within the boundaries of the Adjacent Lands study area but employing different survey methodologies documented extensive evidence of agricultural activities and permanent habitations dating to the Pueblo era, including numerous crescent-shaped pueblos with more than a dozen (up to 20) rooms, as well as field houses, check dams, and other agricultural features (Westfall 1987; Wells 1991). Furthermore, a wealth of archeological sites in the form of rockshelters containing elaborate polychrome rock art (Allen 1988, 1991, 1992; Davenport et al. 1995), seasonal campsites and large complexes of agave

roasting features have been documented on the Esplanade and in tributary canyons in more recent years (Huffman 1993). Other sample surveys conducted elsewhere in the region recorded numerous archeological sites and produced similar or even higher site density projections for the region as a whole (Moffit and Chang 1978, Thompson 1979).

In combination, the results of these various studies demonstrate that the Arizona Strip country adjacent to Grand Canyon National Park contains a wide array of archeological remains dating from the Paleo-Indian period, ca. 6000 BC through post-WW II. Sites include: simple camps consisting of scattered stone chips and charcoal; to isolated caches of pottery; to large 20-room C-shaped pueblos with abundant pottery and associated burials; complexes of agave roasting pits; rockshelters with elaborate polychrome rock art panels, deep limestone caves containing corncobs, feathered arrowshafts, and woven baskets; and historic mines, ranches, and abandoned schoolhouses. The significance of these remains lies not in their artistic or engineering aspects per se, but rather in the complex story they reveal about past human relationships with this harsh landscape (Altschul and Fairley 1989).

Although there is still a great deal to be learned from preserving and studying these tangible remains of past human activities, one fact is already clear: the archeology of the Arizona Strip can not be fully understood or appreciated apart from the human story in Grand Canyon. The people who lived on the Strip were the same ones who created many of the sites in Grand Canyon (Fairley 1989:135-137; Fairley *et al.* 1993; Huffman 1993). Throughout time, people moved between the inner canyon, the pinyon-juniper covered plateaus, and higher conifer-covered mountains in seasonal cycles, taking advantage of the various plants, animals, raw materials, and other resources that could only be found in certain locations or at a particular time of the year. The cycles were not all the same for all cultures or time periods: for some groups, agricultural activities determined when movements could occur, for others travel between various environmental zones was dictated by the seasonal migration of animals and the availability of wild foods. The ability to move between plateau uplands and canyon lowlands was doubtless critical to human survival and success, just as it is for some of the large predators that exist in region today.

Contemporary Tribes: The Escalante-Donninguez expedition of 1776 was the first reported contact with American Indians in the Shivwits Plateau region. The expedition met and traded with resident “Yubuincariri” (Uinkaret Paiute) Indians for “...wild sheep meat, dried cactus prickly pear done into cakes, and seeds from wild plants (Warner 1995:103) near Mt.Trumbull. The Uinkarets told the Spaniards that they did not grow corn, but lived by hunting and gathering, and that only the “Parussis” (Shivwits Paiute) Indians planted corn in the region. However, contact with Anglo-Europeans was devastating to the Southern Paiute Indians. Disease is likely to have reduced the Southern Paiute Indian population by 65% to 90% by 1850 (Fairley 1989). Slave trading was widely practiced by other tribes (particularly the Ute Indians to the east) and by early Anglos, and further decimated and disrupted the Paiute culture.

Navajo, Ute and Paiute conflicts erupted with Anglo ranchers and settlers in the 1860s, culminating in the Black Hawk Navajo Wars of 1866-1869. Following that period, J.W. Powell and G.W. Ingalls visited the Arizona Strip and southwestern Utah in 1871-1872 and reported to Congress on the condition of the Native Americans inhabiting the region (Powell and Ingalls

1874). They found 300 Paiutes in three bands in and around the Shivwits Plateau, with about 40 U-in-kar-ets, 180 Sheav-wits, and 62 Kwai-an-ti-kwoks-ets (the latter affiliated with the Navajo to the east). Powell and Ingalls reported that these bands were the remnants of a larger nation or confederacy that existed prior to Anglo preemption of water sources and high quality land. These bands hunted deer, bighorn sheep and rabbits, gathered seeds and nuts, and raised corn, wheat, beans, melons and squashes of native and European origin. They also subsisted by begging and received government handouts of clothing. Powell and Ingalls (1874) concluded that because of the loss of native lifestyles and their extreme poverty, the federal government should provide the Paiutes with arable land along the Muddy River, and “the Pai-Utes should be made farmers.” Apparently the Paiutes were favorably inclined toward this option. Southern Paiute Indian reservations were subsequently created along the lower Moapa River in Nevada, and near Fredonia, Arizona.

Cultural Anthropology: Anthropological information also has provided insight into Paiute culture, distribution and land use practices on the Shivwits Plateau, information which serves as a provocative contrast to hypothesized life styles of the Virgin River Anasazi, and perhaps provides a reasonable analogue for understanding Paleoindian life styles. Early information was compiled by Sapir (1930) and Kelly (1934), whose studies indicated that individual Paiute bands primarily existed within the confines of their dialects. Subsequent linguistic analyses indicate that their Numic language originated in southeastern California around AD 1000, and the culture radiated eastward across the Great Basin and onto the Colorado Plateau by about AD 1300 (Lamb 1958, Goss 1965). Steward (1938) examined Shoshonean culture, concluding that the harshness of the Arizona Strip terrain and their technological development resulted in a fragmented culture, and restricted social institutions to the nuclear family level. Stewart (1942), Manners (1974) and Euler (1958, 1972) also attempted to define the ethnography and ethnobiology of the aboriginal and post-contact Southern Paiute culture, again relating social development to the harsh environmental conditions.

Ango-European History

Exploration: European exploration of the Shivwits Plateau began in October 1776 with the passage of the Escalante-Dominguez expedition, returning from the Utah Lake area of central Utah (Warner 1995). The expedition traveled southward along the base (west side) of the Hurricane Cliffs, and then turned east into the headwaters of Clayhole Wash in Bobcat Canyon (“Camp San Samuel”, now called “Cooper’s Pockets”) on 18-20 October, north of Mt. Trumbull, where they found much-needed water. Escalante’s thorough descriptions of the landscape and the Indians provided valuable information to subsequent explorers.

After the Escalante-Dominguez expedition, northwestern Arizona was next visited by the Mexican trader, Antonio Armijo in 1829. Armijo, Jedediah Smith, and William Wolfskill (in 1830) were largely responsible for defining the Old Spanish Trail, which subsequently became the most heavily used route for travelers from New Mexico to California. The route ran just north of the Shivwits Plateau region in southern Utah. Captain John C. Fremont also explored and described a portion of the Arizona Strip in 1844.

Detailed exploration of the Shivwits Plateau region was largely accomplished by the Mormons, particularly Jacob Hamblin. Hamblin's 1858 expedition to the Hopi Indian villages passed the north side of the Shivwits Plateau, and his 1862 expedition followed Grand Wash to its mouth, where they forded the river to avoid the hostile Navajo. The following year Hamblin established a route that later became known as "the Colorado Road", a wagon trail from Pigeon Wash to Snap Canyon and into Pearce Wash, with a river crossing at Pearce Ferry. Settlement followed Hamblin's trailblazing efforts, but was interrupted by the Black Hawk Navajo Wars of 1866-1869. Settlement attempted again beginning in 1870. Hamblin's exploration of the Shivwits Plateau region was soon followed by detailed mapping, and settlement. John Wesley Powell's exploits on the Colorado River are well known, and he and Almon Thompson (and Lieutenant George M. Wheeler in a different survey) conducted the first detailed geological surveys of the Shivwits Plateau region.

Settlement: The Shivwits Plateau region saw several settlement attempts, but only a few families have been able to persist in the region. The relative scarcity of both water and mineral deposits limited human activities in the Shivwits Plateau region to cattle grazing, largely unsuccessful mining operations, and some logging at higher elevations. No permanent communities exist in or particularly near the proposed monument. In 1864, an intrepid group of Mormons established the "town" of Millersville on the banks of the Virgin River near its confluence with Beaver Dam Wash. A severe flood two years later forced the pioneers to abandon the community, later renamed Beaver Dams because the furbearers dammed the settlers' irrigation systems. Ten years passed before several Mormon families established the community of Littlefield just below the ill-fated Beaver Dams (House 1986). The region's history is also related to the flight of traditional Mormon families after polygamy was outlawed (Cox and Russell 1973).

The town of Mount Trumbull ("Bundyville") at the southern end of the Hurricane Cliffs in "Cactus Flat" was settled in 1916. The community supported a school, a store and consisted of the Bundy, Eslin, Iverson, Vanleuven and more than a dozen other families, cowboys, sheep herders, school teachers, postal workers and cattle inspectors. However, the lack of water, sparse resources, harsh climate, federal restrictions on grazing, and difficult access eventually took its toll on the community, and it was abandoned in the late 1960's (Cox and Russell 1973). The lives and travails of these and other early settlers in the region were documented by Larsen (1961), Cox and Russell (1973), Belshaw (1978), House (1986), and other authors, all of whom emphasize the living history of the region, and the importance of the land to modern residents of surrounding communities.

Ranching History: Early cattle operations on the Arizona Strip, such as that of James Whitmore at Pipe Springs, ended in disaster as raiding Navajos and Paiutes fought to regain their land and water (Lavender 1984). However, federal persecution and negotiations ended the Indian uprisings in the late 1860s and early 1870s. Peace allowed small grazing operations to spring up, and ranching in the Shivwits Plateau region began with the establishment of the Whitmore ranch near Oak Spring on the flanks of Mt. Logan. This ranch drew water from Mt. Logan and from Whitmore (Big) Spring on the south side of Mt. Logan. Larsen (1961:247) documented the early ranching history on the Shivwits Plateau:

“There was...the Mohave Stock Company which operated near Parashont (sic) Ranch about eight or ninety miles south of St. George on the Arizona Strip. Andrew Sorenson, John Pymm, the Foremaster Brothers --David, Ephraim, Albert-- and others established themselves in this area. James W. Nixon and others established others on Mt.Trumbull at quite an early date...Anthony Ivins acquired the Parashont Ranch from B.F. Saunders. He sold it to Preston Nutter who became the biggest cattleman on the Arizona Strip.”

Cattle barons, such as B.F. Saunders and Preston Nutter, took control of the water sources in the two decades before and after the turn of the century, forcing out many of the small cattle and sheep operations.

Beginning in the 1870's, these and other grazing operations activities denuded the Shivwits Plateau region, as well as the entire Four Corners area. Overgrazing during the next two decades resulted in denudation of the Shivwits Plateau, a condition from which most of its rangelands have never recovered. The Taylor Grazing Act was enacted in 1934 to: (1) “stop injury to the public lands by preventing overgrazing; (2) to provide for their orderly use, improvement, and development...(and 3) to stabilize the livestock industry dependent upon the public range” (Calef 1960:5). This act asserted federal control over rangelands, and guided development of the Department of Interior Bureau of Land Management (Altschul and Fairley 1989). The act was the major cause of abandonment of homesteads on the Arizona Strip during the late 1930's (Belshaw 1978).

Ranching provides a rich history, but poor economic return for the few Shivwits Plateau residents (Cox and Russell 1973, Lavender 1984, House 1986). One study attributes severely overgrazed conditions to past unrestricted grazing and describes the majority of the range as in fair or poor condition, with the riparian canyon bottoms especially degraded (USDI 1981). While some accounts (USDI 1981:11) describe cattle ranching on the Strip as a major economic force in the region, a recent GAO report (1991:47) indicates grazing in Washington County accounts for only 5% of the county's personal income and generally requires economic subsidy. Ranchers prefer ranching as a way of life, despite the small earnings and the need for many to supplement their income with outside work. The main concern of many operators is to cover operating cash costs (GAO 1991:49). The Government Accounting Office (GAO 1991), referencing the BLM's Shivwits Resource Area EIS, concluded that the potential loss of employment under the “no livestock grazing alternative” would be less than one percent of the employment in Washington and Kane counties, Utah, as well as in parts of Mohave and Coconino counties, Arizona. Today the largest commercial operation is undoubtedly Tony Heaton's Bar Ten Ranch, a working ranch that provides accommodations for visitors to Grand Canyon river trips.

Mining History: Mining has had a long and colorful history in the Shivwits Plateau region. Mining operations in the Shivwits Plateau region largely focused on copper, and three mining districts exist (Belshaw 1979, Fairley 1989, Billingsley et al. 1997): the Mt. Trumbull District on the central Shivwits and southwestern Uinkaret plateaus; the Centennial District from Mt. Dellenbaugh south to the Colorado River and including all of Kelly Point; and the Bently District on the southwestern Shivwits and the Sanup plateaus. Three claims and several prospects are

known in the Mt. Trumbull District, including the Chapel, Copper House, and Copper Mountain mines. The latter was established south of Mt. Trumbull in 1875, and produced the only significant quantity of silver on the Arizona Strip. The Bently District contains several mines and prospects. The Grand Gulch Mine was filed in 1873 by Richard Bentley and others and was an active copper mine until the conclusion of World War I, and briefly during and after World War II. During its first period of activity, the ore was trucked by wagon through St. Thomas to St. George. Other mining operations in Grand Wash include the Savanic, Hidden Canyon and Cunningham mines, located along the Grand Wash Cliffs. An active operation presently exists along the east side of Grand Wash. The Centennial District contains only the Snyder Mine in Grand Canyon, but recent uranium exploration has occurred in upper Parashant Canyon. All mines in the Shivwits Plateau region suffered from poor and difficult access, and most of the copper mines closed when copper prices plummeted after World War I. Many have been reconsidered for uranium, but little activity is presently occurring.

Lumbering: Construction of the Mormon Temple in St. George began in 1871 and required massive amounts of lumber. The Temple Trail was constructed in April and May 1874 along the west side of the Hurricane Cliffs to Nixon Spring at Mt. Trumbull, and the saw mills there produced more than one million board-feet of lumber for the temple project. Two years later the steam mills, originally brought from Salt Lake, were dismantled and moved to Mormon Lake near Flagstaff, Arizona. Ranchers established another mill sometime later, which remained in operation until 1940. At present, the Mt. Trumbull ponderosa pine forest is being studied to determine how to restore pre-settlement stand structure (Moore et al. 1999).

LANDSCAPE CONSERVATION OF THE SHIVWITS PLATEAU REGION

Nine Characteristics

The information presented in this report identifies nine geological, biological and cultural characteristics of the Shivwits Plateau region that may be relevant to the discussion of enhanced federal protection. These include the region's: 1) position encompassing the continentally significant boundary between the Basin and Range and the Colorado Plateau Geologic Provinces; 2) its paleoecological significance as a landscape demonstrating vegetation responses to global climate change over the past 50,000 years, and which has produced a world-class stepped ecotone along the Grand Wash Cliffs; 3) its value as a refuge for endemic species and 4) for sensitive and game species; 5) its two large north-south escarpments, which may serve as a corridor for migratory raptors and other species; 6) its scientific and management value in wildlife population and landscape restoration; 7) nearly 8000 years of occupation by American Indians; 8) its colorful human history since 1776; and 9) its vast, rarely-visited and little-developed character with tremendous scenic value. These elements are described below.

A Remarkable Geologic Boundary

The Shivwits Plateau region bridges one of the most profound geological boundaries in the United States, bridging the Basin and Range Geologic Province with the Colorado Plateau to the

east. The intensely faulted Basin and Range is the only active rift on earth not under water, and lies beside the uplifted but nearly unbroken Colorado Plateau. The transition between these two geologic provinces is exquisitely exposed, providing geologists with evidence of the dynamics of geological processes. In recent geologic time, the crustal extension expressed in the Basin and Range province has begun to stretch the western margin of the Colorado Plateau. This has resulted in a series of long parallel, curvilinear faults and associated cliffs, slicing north to south through the Shivwits Plateau region. At the plateau's western edge, the Grand Wash fault juxtaposes the colorful, lava-capped Precambrian and Paleozoic strata of the Grand Canyon against the highly faulted terrain, recent lake beds, and desert volcanic peaks of the downdropped Grand Wash trough. This region holds the key to the geological division of these two great geologic provinces and the landscape evolution of the lower Colorado River.

The Shivwits Plateau region reveals much about the development of Grand Canyon. Uplifting of the southern margin of the Colorado Plateau reversed drainage directions and allowed the Colorado River to cut across the terrain. The Colorado River system integrated with the developing Gulf of California, creating a through-flowing river. The timing of canyon cutting is recorded in the volcanic rocks of the Shivwits Plateau. Some of these flowed as lavas into a deep Grand Canyon, post-dating its earliest downcutting about 5 million years ago. Other lava flows predated Grand Canyon, because they were incised and truncated by the deepening gorge. Despite years of study, there is still much to be learned about the timing and evolution of the Colorado River and Grand Canyon, and the critical data lie, at least in part, on the Shivwits Plateau.

Climate Change and Ecotone Ecology in a Natural Laboratory

Dramatic Changes: A remarkable paleoecological transformation of the Shivwits Plateau ecotone has occurred over the past 50,000 years. The western margin of the Shivwits Plateau marks the boundary between the Sonoran/ Mojave/Great Basin floristic provinces to the west, with the Maderan province to the south, and the Intermountain province to the northeast. Analysis of ancient packrat middens and cave deposits has revealed that the pinyon-juniper treeline rose 3,000 feet upslope in less than 7,000 years during the Pleistocene-Holocene transition, as a warmer, drier climate developed. These environmental shifts resulted in the mixing of plant species from the surrounding ecosystems and biomes. Environmental and floristic changes, coupled with the arrival of early humans, resulted in the extinction of the Pleistocene megafauna – elephants, camels, mountain goats, large predators, and giant birds that roamed the plateaus and lowlands, prior to natural desertification. Great concern exists regarding ecological processes and responses to global climate change, and the Shivwits Plateau region provides a unique natural laboratory in which to study and understand these changes.

Contemporary Ecosystems: Grand Wash, the Sanup Plateau and the Grand Wash Cliffs form one of the nation's most distinctive ecotones, an ecological transition from the Mojave Desert to boreal coniferous forests. The contemporary vegetation of the Shivwits region consists of several distinct assemblages: 1) desert creosote bush and white bursage in Grand Wash; 2) desert riparian Fremont cottonwood, Goodding willow, and mesquite at springs; 3) a regionally unusual assemblage of Joshua tree, blackbrush, Utah juniper, and various cacti on the middle elevation Sanup Plateau; chaparral-oak shrub and woodland on south-facing slopes; 4) widespread stands of

pinyon pine and Utah juniper in vast woodlands on the plateau; 5) remnant short-grass prairie to the north and east; 6) stands of bigtooth sagebrush and snakeweed in natural and altered meadows, particularly on grazing-disturbed uplands; 7) ponderosa pine at higher elevations; and 8) upland riparian vegetation around Plateau springs.

Biological Hotspots

Desert and plateau springs may be regionally important biological hot spots that protect endemic species. The BLM manages at least 43 springs on the southern half of the Shivwits Plateau, and Lake Mead National Recreation Area manages several dozen additional springs. Many BLM springs have been greatly altered by human activities, with discharge diverted or abstracted. Springs and seeps in the Southwest are hot spots for biodiversity: aquatic and land snails, pillbugs, *Hyallela* amphipids and various amphibians require spring habitats, and are prone to endemism in these habitats. For example, Tassi, Grapevine and Whiskey springs on Grand Wash support populations of numerous summer resident Neotropical songbird species, as well as woodpeckers, Gamble quail and the endemic Grand Wash spring snail. However, Shivwits Plateau and Grand Wash springs biota have not been systematically inventoried.

A Refuge for Rare and Game Species

The Shivwits Plateau region supports at least 232 plant species, at least one fish species, numerous but poorly documented amphibian and reptile species, 115 bird species, and 49 mammal species. A total of 59 (>5%) species that do or may occur in the region are recognized as rare and sensitive species of concern to the State of Arizona, the U.S. Fish and Wildlife Service, and other federal agencies. The extent of migratory and upland species using the Shivwits Plateau and its western periphery as winter range is presently unknown, but also may be of conservation interest. The northwestern portion of the Shivwits is managed as desert tortoise habitat. Game populations include wild turkey, desert mule deer, desert bighorn sheep, and pronghorn in this region. Winter waterbird populations (including bald eagle) on upper Lake Mead and its shorelines are substantial, but are poorly documented.

An Important Migratory Corridor?

Long, north-south aligned escarpments define the Shivwits Plateau, with the Grand Wash Cliffs on the west and the Hurricane Cliffs to the east. Long north-south aligned cliffs such as these commonly provide migratory pathways for hawks and other species. A large number of raptors migrate through southern Nevada and use upwardly-rising air currents that develop as daytime mountain winds along cliff lines. Although not well documented, our single reconnaissance in October 1999 detected at least 5 raptor species, with 0.1 raptors/km and 9 birds/hr. These preliminary data suggest use of the escarpments by raptors, but more thorough surveys are needed to provide better resolution of the extent, timing and daily variability of migratory species. The Shivwits region also may provide seasonal access corridors for large mammals, such as desert mule deer, desert bighorn sheep, and mountain lion from lowland to upland habitats, through drainages such as Pigeon and Hidden canyons; however, the movement patterns of large Shivwits Plateau mammals are poorly known.

Population and Landscape Restoration Ecology

Restoration ecology is being explored and implemented in the Shivwits region through several different projects. 1) The Mt. Trumbull Resource Conservation Area is a ponderosa pine forest in which fire suppression, grazing and logging have altered forest structure and composition. The pre-settlement fire frequency was 3-5 yr, but fire suppression has allowed fuel loads to accumulate, threatening this ecosystem with potentially devastating fires. The Mt. Trumbull RCA is being used to scientifically test forest restoration options in an interagency effort spearheaded by W.W. Covington and his associates at Northern Arizona University. 2) Eighteen young endangered California condors have been released from a site on the Hurricane Cliffs 36 miles south of St. George, UT as part of the on-going California condor re-introduction program, and additional releases are planned. 3) Pronghorn populations declined on the northern half of the Shivwits Plateau until the populations were augmented in the 1960's by the Arizona Game Fish Department. Pronghorn numbered 150-200 head in 1998, and the success of the pronghorn program has allowed the AGFD to issue hunting permits since 1977. The desert bighorn sheep population is increasing as well, as on-going collaboration between BLM and AGFD has initiated population augmentation in the northern Shivwits region. 4) Non-native tamarisk, an invasive woody tree, has been removed from several desert springs along Grand Wash, a remarkably successful program lead by the National Park Service at Lake Mead National Recreation Area and underway by the BLM at several of its low elevation springs. 5) The desert tortoise is a focal species for habitat management along the western edge of the Shivwits Plateau. Several habitat conservation areas have been established and are being monitored by the BLM in St. George, Utah and the northern Sanup Plateau area may provide excellent habitat for desert tortoise, and is being managed for that species by the BLM. Overall, these population and ecosystem management activities demonstrate that the Shivwits region is an extraordinary natural laboratory in which to test and apply the principles of conservation and restoration ecology.

Protection of large land areas is often a primary goal in conservation biology to maintain the full complement of native species in the region, to allow for natural processes such as fire, to accomodate species range shifts in response to climate change, and to protect large predators and ungulate species, which have large home range requirements (Meffe and Carroll 1997). The Shivwits Plateau region is a large, remote, and relatively intact landscape, and this is one of its most significant ecological features. However, habitat for large predators is not in itself a sufficient argument for additional protection of the region. There is little evidence that some large predators in the region (i.e., black bear and the now extirpated Great Basin gray wolf) occurred in great numbers, or that others (i.e., mountain lion and bobcat) occurred in high densities prior to settlement. However, additional landscape protection is expected to result in increased large predator populations in the region.

Archeology

Much of the current understanding of Shivwits Plateau region archeology is based on small-scale, superficial surveys, rather than on broad or detailed assessments. However, existing research has revealed quarries, campsites and chipping areas dating from the Archaic period (ca. 2500 to 300 BC), as well as numerous crescent-shaped pueblos with 12-20 rooms, field houses,

check dams, other agricultural features, *Agave* roasting pits of the Basketmaker II to Pueblo III periods (ca. AD500-1150), and Southern Paiute occupation (ca. AD 1250-1880). Pictograph sites, caves (including some with feathered arrowshafts, sandals, and woven baskets) and rockshelters containing elaborate rock art have been discovered. Preliminary data suggested that this region was primarily used for seasonal hunting and gathering, and was marginal for horticulture; however, subsequent and more intensive studies have documented extensive evidence of Puebloan agricultural activities and permanent habitations. Conservation and further inventory and study of these sites and remains will elucidate the complex relationships between early humans in the Shivwits Plateau and Grand Canyon regions. These sites and remains are considered by contemporary American Indians to be significant cultural properties.

Exploration and Settlement History

The color and harshness of the Shivwits Plateau region is strongly reflected in its exploration and settlement history. The Escalante-Dominguez Expedition of 1776 passed along the Hurricane Cliffs and made first contact with the Uinkaret Paiute Indians. Early mountain men and explorers, including Jedediah Smith (1826, 1827), Antonio Armijo (1829) and William Wolfskill (1830) were largely responsible for defining the Old Spanish Trail just north of the Shivwits Plateau, which subsequently became the most heavily used route for travelers from New Mexico to California. Mormon explorer, Jacob Hamblin documented access routes and establish contact with resident Paiute Indians from 1858 through 1863. John Wesley Powell documented approximately 300 Paiutes in three bands in the region in 1874. Early cattle operations, such as that of James Whitmore, ended in disaster as raiding Navajos and Paiutes fought to regain lost lands; however, federal military actions and negotiations ended the Indian uprisings in the 1880's. Peace allowed small grazing operations to spring up, but cattle barons, such as B.F. Saunders and Preston Nutter, eventually took control of the water sources in the two decades before and after the turn of the 20th century, forcing out many of the small cattle operations. A lumber mill was operated on Mt. Trumbull to provide lumber for the Mormon Temple in St. George, Utah, and later these highest peaks were commercially logged. The region's settlement history is also related to the flight of traditional Mormon families after polygamy was outlawed. The only significant settlement on the Shivwits Plateau was the town of Mt. Trumbull (or "Bundyville"), which once numbered nearly 300 residents, and lasted for five decades before the residents finally abandoned the harsh, waterless site. At present, Government Accounting Office data indicate that grazing contributes less than one percent of the employment in Washington and Kane counties, Utah, as well as in parts of Mohave and Coconino counties, Arizona. The largest commercial operation on the Shivwits Plateau is Tony Heaton's Bar Ten Ranch, a working ranch that provides accommodations for visitors emerging from or headed in to Grand Canyon river trips. In addition, several active mines exist on the Sanup Plateau.

A Vast, Scenic Landscape

The Shivwits Plateau region is a truly vast and largely undeveloped landscape. It is one of the least visited parts of the United States. The Hurricane Cliffs are one of the longest individual escarpments in North America, extending far north and south of the Shivwits region. Off the dramatic Grand Wash Cliffs to the west, the Sanup Plateau forms a world-class stepped ecotone.

The Shivwits Plateau, its escarpment margins, and the surrounding lands, have exceptional regional and global scenic value, and are among the most remote lands remaining in the coterminous United States.

Summary

The Shivwits Plateau region appears to be worthy of, and available for, enhanced federal protection. Our landscape analysis indicates that significant geological, biological and human history features and processes exist in this region, and additional research in the region is likely to contribute substantial additional information to understanding the processes and impacts of geological, biogeographic and global environmental change. These objects, features, and scientific opportunities, coupled with the overall high ecological integrity of most of the landscape, its low human population density and development, and its few extractable resources, make the Shivwits Plateau a reasonable target for enhanced protection. The region has outstanding scenic value, particularly its eastern, southern and western escarpments. Enhanced protection of the Shivwits Plateau region will help buffer Grand Canyon National Park from the impacts of rapid population expansion in southern Utah (i.e., St. George, Cedar City) and Nevada (Las Vegas, Mesquite). In addition, the recently revised expansion of the proposed monument boundaries would help protect and link the prominent north-south escarpments, springs and wildlife movement corridors, the Sanup Plateau and the Grand Wash drainage. The revised boundaries would provide for better landscape linkage among the region's four Wilderness Areas, and would protect additional desert tortoise, antelope, or desert bighorn sheep habitats on the northwestern Shivwits Plateau region.

Much remains to be learned about the Shivwits Plateau region, and future inventories and studies are likely to substantially increase the list of species and identify important, as yet unrecognized, ecological processes. Such data are likely to further strengthen the rationale for preserving this geologically, biologically and anthropologically outstanding landscape.

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Appendix 1: Plants of the Shivwits Plateau and vicinity (data from Lake Mead National Recreation Area 1979).

Family	Genus	Species	Author	Common Name
Aceraceae	<i>Acer</i>	<i>negundo</i>	L.	box-elder
Agavaceae	<i>Agave</i>	<i>utahensis</i>	Engelm.	agave
Amaranthaceae	<i>Amaranthus</i>	<i>blitoides</i>	Wats.	amaranth
Amaranthaceae	<i>Amaranthus</i>	<i>fimbriatus</i>	(Torr.) Benth.	amaranth
Amaryllidaceae	<i>Allium</i>	<i>acuminatum</i>	Hook.	wild onion
Amaryllidaceae	<i>Allium</i>	<i>bisceptrum</i>	Wats.	wild onion
Anacardiaceae	<i>Rhus</i>	<i>trilobata</i>	Nutt. ex T. & G.	
Apiaceae	<i>Cymopterus</i>	<i>multinervatus</i>	(Coult. & Rose) Tides.	
Apiaceae	<i>Cymopterus</i>	<i>purpurascens</i>	(Gray) Jones	
Apiaceae	<i>Lomatium</i>	<i>macdougali</i>	Coult. & Rose	
Apiaceae	<i>Lomatium</i>	<i>nevadense</i> var. <i>parishii</i>	(Wats.) Coult. & Rose (Coult. & Rose) Jeps.	
Apocynaceae	<i>Amsonia</i>	<i>tomentosa</i>	Torr. & Frem.	
Apocynaceae	<i>Apocynum</i>	<i>sibiricum</i> var. <i>salignum</i>	Jacq. (Greene) Fern.	dogbane
Asclepiadaceae	<i>Asclepias</i>	<i>asperula</i>	(Decne.) Woodson	milkweed
Asclepiadaceae	<i>Asclepias</i>	<i>subverticillata</i>	(Gray) Vail	milkweed
Aspidiaceae	<i>Woodsia</i>	<i>oregana</i>	Eat.	
Asteraceae	<i>Agoseris</i>	<i>glauca</i> var. <i>parviflora</i>	(Pursh) Greene (Nutt.) Rydb.	
Asteraceae	<i>Artemisia</i>	<i>bigelovii</i>	Gray	
Asteraceae	<i>Artemisia</i>	<i>frigida</i>	Willd.	estafiata
Asteraceae	<i>Artemisia</i>	<i>tridentata</i>	Nutt.	big sagebrush
Asteraceae	<i>Aster</i>	<i>adscendens</i>	Lindl. in Hook.	aster
Asteraceae	<i>Baileya</i>	<i>multiradiata</i>	Harv. & Gray	desert-marigold
Asteraceae	<i>Brickellia</i>	<i>californica</i>	(Torr. & Gray) Gray	
Asteraceae	<i>Brickellia</i>	<i>longifolia</i>	Wats.	
Asteraceae	<i>Chaenactis</i>	<i>douglasii</i>	(Hook.) Hook. & Arn.	
Asteraceae	<i>Chrysothamnus</i>	<i>depressus</i>	Nutt.	
Asteraceae	<i>Chrysothamnus</i>	<i>nauseosus</i>	(Pall.) Britton	rabbit-brush
Asteraceae	<i>Cirsium</i>	<i>arizonicum</i>	(Gray) Petrak	thistle
Asteraceae	<i>Cirsium</i>	<i>neomexicanum</i>	Gray	thistle
Asteraceae	<i>Conyza</i>	<i>canadensis</i>	(L.) Cronq.	horseweed

Asteraceae	<i>Crepis</i>	<i>intermedia</i>	Gray	hawks-beard
Asteraceae	<i>Erigeron</i>	<i>divergens</i>	Torr. & Gray	fleabane
Asteraceae	<i>Erigeron</i>	<i>pumilus ssp. concinnoides</i>	Nutt. Cronq.	fleabane
Asteraceae	<i>Erigeron</i>	<i>utahensis</i>	Gray	fleabane
Asteraceae	<i>Gutierrezia</i>	<i>microcephala microcephala</i>	(DC.) Gray Greene	snake-weed
Asteraceae	<i>Helianthus</i>	<i>ciliaris</i>	DC.	sunflower
Asteraceae	<i>Hymenopappus</i>	<i>lugens</i>	Greene	
Asteraceae	<i>Hymenoxys</i>	<i>acaulis var. arizonica</i>	(Pursh) (Greene) Parker	
Asteraceae	<i>Hymenoxys</i>	<i>Cooperi</i>	(Gray) Cockerell	
Asteraceae	<i>Hymenoxys</i>	<i>richardsonii var. floribunda</i>	(Hook.) Cockerell (Gray) Parker	
Asteraceae	<i>Laphamia</i>	<i>congesta</i>	Jones	
Asteraceae	<i>Leucelene</i>	<i>ericoides</i>	(Torr.) Greene	
Asteraceae	<i>Machaeranthera</i>	<i>canescens</i>	(Pursh) Gray	
Asteraceae	<i>Porophyllum</i>	<i>gracile</i>	Benth.	
Asteraceae	<i>Psilostrophe</i>	<i>sparsiflorus</i>	(Gray) Nels.	paperflower
Asteraceae	<i>Sanvitalia</i>	<i>abertii</i>	Gray	
Asteraceae	<i>Senecio</i>	<i>longilobus</i>	Benth	groundsel
Asteraceae	<i>Senecio</i>	<i>multilobatus</i>	Torr. & Gray	groundsel
Asteraceae	<i>Solidago</i>	<i>Ssarsiflora</i>	Gray	goldenrod
Asteraceae	<i>Taraxacum</i>	<i>officinale</i>	Wiggers	dandelion
Asteraceae	<i>Thelesperma</i>	<i>subnudum</i>	Gray	
Asteraceae	<i>Townsendia</i>	<i>exscapa</i>	(Richards) Porter	
Asteraceae	<i>Tragopogon</i>	<i>dubius</i>	Scop.	goats-beard
Asteraceae	<i>Viguiera</i>	<i>multiflora</i>	(Nutt.) Blake	
Berberidaceae	<i>Berberis</i>	<i>fremontii</i>	Torr.	barberry
Boraginaceae	<i>Cryptantha</i>	<i>confertiflora</i>	(Greene) Pays.	
Boraginaceae	<i>Cryptantha</i>	<i>gracilis</i>	Osterh.	
Boraginaceae	<i>Lappula</i>	<i>occidentalis</i>	(Wats.) Greene	stickseed
Boraginaceae	<i>Lithospermum</i>	<i>incisum</i>	Lehm.	puccoon

Brassicaceae	<i>Arabis</i>	<i>gracilis</i>	Greene	rock-cress
Brassicaceae	<i>Arabis</i>	<i>perennans</i>	Wats.	rock-cress
Brassicaceae	<i>Capsella</i>	<i>bursa-pastoris</i>	(L.) Medic.	shepherd's-purse
Brassicaceae	<i>Descurainia</i>	<i>obtusa</i>	(Greene) O.E. Schultz	tansy-mustard
Brassicaceae	<i>Draba</i>	<i>cuneifolia</i>	Nutt. ex T. & G.	
Brassicaceae	<i>Erysimum</i>	<i>repandum</i>	L.	wallflower
Brassicaceae	<i>Lepidium</i>	<i>montanum</i>	Nutt.	pepper-grass
Brassicaceae	<i>Lesquerella</i>	<i>intermedia</i>	(Wats.) Heller	bladder-pod
Brassicaceae	<i>Sisymbrium</i>	<i>ambiguum</i>	(Wats.) Pays.	
Brassicaceae	<i>Stanleya</i>	<i>pinnata</i>	(Pursh) Britton	prince's plume
Brassicaceae	<i>Streptanthus</i>	<i>cordatus</i>	Nutt.	
Brassicaceae	<i>Thelypodium</i>	<i>wrightii</i>	Gray	
Cactaceae	<i>Coryphantha</i>	<i>vivipara</i> var. <i>arizonica</i>	(Nutt.) Britt. & Rose (Engelm.) W.T. Marshall	
Cactaceae	<i>Echinocereus</i>	<i>engelmannii</i> var. <i>chrysocentrus</i>	(Parry) Lem. (Engelm.) Engelm. ex Rumpler	hedgehog cactus
Cactaceae	<i>Echinocereus</i>	<i>triglochidiatus</i> var. <i>melanacanthus</i>	Engelm. (Engelm.) L. Benson	mound cactus
Cactaceae	<i>Echinocereus</i>	<i>triglochidiatus</i> var. <i>mohavensis</i>	Engelm. (Engelm. & Bigel.) Benson	mound cactus
Cactaceae	<i>Opuntia</i>	<i>acanthocarpa</i> var. <i>coloradensis</i>	Engelm. & Bigel. Benson	cholla
Cactaceae	<i>Opuntia</i>	<i>macrorhiza</i>	Engelm.	
Cactaceae	<i>Opuntia</i>	<i>phaeacantha</i> var. <i>major</i>	Engelm. Engelm.	
Cactaceae	<i>Opuntia</i>	<i>whipplei</i> var. <i>whipplei</i>	Engelm. & Bigel	
Cactaceae	<i>Pediocactus</i>	<i>simpsonii</i>	(Engelm.) Britt. & Rose	
Capparaceae	<i>Cleome</i>	<i>lutea</i>	Hook.	
Capparaceae	<i>Cleome</i>	<i>serrulata</i>	Pursh	
Caprifoliaceae	<i>Symphoricarpos</i>	<i>longiflorus</i>	Gray	snowberry
Caprifoliaceae	<i>Symphoricarpos</i>	<i>parishii</i>	Rydb.	snowberry
Caryophyllaceae	<i>Arenaria</i>	<i>aberrans</i>	Jones	sandwort
Caryophyllaceae	<i>Arenaria</i>	<i>macradenia</i>	Wats.	sandwort
Caryophyllaceae	<i>Arenaria</i>	<i>macradenia</i>	Wats.	sandwort
Celastraceae	<i>Mortonia</i>	<i>utahensis</i>	(Cov.) A. Nels.	

Chenopodiaceae	<i>Atriplex</i>	<i>canescens</i>	(Pursh) Nutt.	
Chenopodiaceae	<i>Chenopodium</i>	<i>album</i>	L.	lamb's-quarters
Chenopodiaceae	<i>Chenopodium</i>	<i>berlandieri</i>	Moq.	
Chenopodiaceae	<i>Monolepis</i>	<i>nuttalliana</i>	(Schult.) Greene	
Convolvulaceae	<i>Convolvulus</i>	<i>arvensis</i>	L.	bind-weed
Cupressaceae	<i>Juniperus</i>	<i>osteosperma</i>	(Torr.) Little	Utah juniper
Cyperaceae	<i>Carex</i>	<i>occidentalis</i>	Bailey	sedge
Elaeagnaceae	<i>Sherpherdia</i>	<i>rotundifolia</i>	Parry	buffalo-berry
Ephedraceae	<i>Ephedra</i>	<i>nevadensis</i>	Wats.	Mormon-tea
Ericaceae	<i>Arctostaphylos</i>	<i>oungens</i>	HBK.	manzanita
Euphorbiaceae	<i>Euphorbia</i>	<i>albomarginata</i>	T. & G.	spurge
Euphorbiaceae	<i>Euphorbia</i>	<i>incisa</i>	Engelm.	spurge
Fabaceae	<i>Astragalus</i>	<i>amphioxys</i>	Gray	milk-vetch
Fabaceae	<i>Astragalus</i>	<i>calycosus</i> var. <i>scaposus</i>	Torr. (Gray) Jones	milk-vetch
Fabaceae	<i>Astragalus</i>	<i>humistratus</i>	Gray	milk-vetch
Fabaceae	<i>Astragalus</i>	<i>lentiginosus</i> var. <i>palans</i>	Dougl. Jones	milk-vetch
Fabaceae	<i>Astragalus</i>	<i>lentiginosus</i> var. <i>vitreus</i>	Dougl. Barneby	milk-vetch
Fabaceae	<i>Astragalus</i>	<i>oophorus</i> var. <i>caulescens</i>	Wats. Jones	milk-vetch
Fabaceae	<i>Calliandra</i>	<i>humilus</i> var. <i>reticulata</i>	Benth. Benson	fairy-duster
Fabaceae	<i>Dalea (Petalostemon)</i>	<i>candida candidum</i>	(Michx.) Willd. Michx.	prairie-clover
Fabaceae	<i>Dalea (Petalostemon)</i>	<i>searlsiae searlsiae</i>	(Gray) Barneby Gray	prairie-clover
Fabaceae	<i>Desmanthus</i>	<i>cooleyi</i>	(Eaton) Trel.	
Fabaceae	<i>Lathyrus</i>	<i>eucosmus</i>	Butters & St. John	pea
Fabaceae	<i>Lotus</i>	<i>wrightii</i>	(Gray) Greene	deer-vetch
Fabaceae	<i>Lupinus</i>	<i>argenteus</i>	Pursh.	lupine
Fabaceae	<i>Lupinus</i>	<i>hillii</i>	Greene	lupine
Fabaceae	<i>Lupinus</i>	<i>kingii</i>	Wats.	lupine
Fabaceae	<i>Melilotus</i>	<i>officinalis</i>	(L.) Lam.	sweet-clover
Fabaceae	<i>Psorelea</i>	<i>tenuiflora</i>	Pursh	scurf-pea

Fabaceae	<i>Psoralea</i>	<i>fremontii</i> var <i>fremontii</i>	(Torr.) Barneby Torr. ex Gray	indigo bush
Fabaceae	<i>Robinia</i>	<i>neomexicana</i>	Gray	
Fabaceae	<i>Vicia</i>	<i>exigua</i>	Nutt. in T. & G.	vetch
Fagaceae	<i>Quercus</i>	<i>gambelii</i>	Nutt.	gambel oak
Fagaceae	<i>Quercus</i>	<i>turbinella</i>	Greene	shrub oak
Fagaceae	<i>Quercus</i>	<i>undulata</i>	Torr.	wavyleaf oak
Fouquieriaceae	<i>Fouquieria</i>	<i>splendens</i>	Engelm.	
Fumariaceae	<i>Corydalis</i>	<i>aurea</i>	Willd.	
Garryaceae	<i>Garrya</i>	<i>flavescens</i>	Wats.	silk-tassel
Gentianaceae	<i>Frasera</i>	<i>albomarginata</i>	Wats.	green gentian
Geraniaceae	<i>Geranium</i>	<i>caespitosum</i>	Jones	geranium
Geraniaceae	<i>Geranium</i>	<i>richardsonii</i>	Fisch. & Trautv.	geranium
Hydrophyllaceae	<i>Phacelia</i>	<i>fremontii</i>	Torr.	
Hydrophyllaceae	<i>Phacelia</i>	<i>ivesiana</i>	Torr.	
Hydrophyllaceae	<i>Phacelia</i>	<i>palmeri</i>	Torr.	
Lamiaceae	<i>Marrubium</i>	<i>vulgare</i>	L.	horehound
Lamiaceae	<i>Moldavica</i>	<i>parviflora</i>	(Nutt.) Britton	dragon-head
Liliaceae	<i>Calochortus</i>	<i>nuttallii</i>	Torr.	mariposa-lily
Liliaceae	<i>Fritillaria</i>	<i>atropurpurea</i>	Nutt.	fritillary
Liliaceae	<i>Leucocrinum</i>	<i>montanum</i>	Nutt. ex A. Gray	star-lily
Linaceae	<i>Linum</i>	<i>aristatum</i>	Engelm.	flax
Linaceae	<i>Linum</i>	<i>lewisii</i>	Pursh	flax
Loasaceae	<i>Mentzelia</i>	<i>albicaulis</i>	(Hook.) T. & G.	
Loasaceae	<i>Mentzelia</i>	<i>pumila</i>	(Nutt.) Torr. & Gray	
Malvaceae	<i>Eremalche Malvastrum</i>	<i>exilis exile</i>	(Gray) Greene Gray	
Malvaceae	<i>Malva</i>	<i>neglecta</i>	Wallr.	cheese-weed
Malvaceae	<i>Sphaeralcea</i>	<i>ambigua</i>	Gray	globe-mallow
Malvaceae	<i>Sphaeralcea</i>	<i>grossulariaefolia</i>	(Hook. & Arn.) Rydb.	globe-mallow
Nyctaginaceae	<i>Oxybaphus</i>	<i>coccineus</i>	Torr.	

Oleaceae	<i>Forestiera</i>	<i>neomexicana</i>	Gray	desert-olive
Oleaceae	<i>Fraxinus</i>	<i>cuspidata</i> var. <i>macropetala</i>	Torr. (Eastw.) Rehder	ash
Oleaceae	<i>Fraxinus</i>	<i>pennsylvanica</i> ssp. <i>velutina</i>	Marshall (Torr.) G. N. Miller	
Oleaceae	<i>Menodora</i>	<i>scabra</i>	Gray	
Onagraceae	<i>Calylophus</i>	<i>hartwegii</i> var. <i>hartwegii</i>	(Benth.) Raven	evening-primrose
Onagraceae	<i>Calylophus</i>	<i>hartwegii</i> ssp. <i>lavandulifolius</i>	(Benth.) Raven (T. & G.) Towne & Raven	evening-primrose
Onagraceae	<i>Epilobium</i>	<i>hornemannii</i>	Reichenb.	willow-weed
Onagraceae	<i>Gayophytum</i>	<i>ramosissimum</i>	T. & G.	
Onagraceae	<i>Oenothera</i>	<i>flava</i>	(Nels.) Garrett	evening-primrose
Orobanchaceae	<i>Orobanche</i>	<i>fasciculata</i>	Nutt.	broom-rape
Pinaceae	<i>Pinus</i>	<i>edulis</i>	Engelm.	pinyon pine
Pinaceae	<i>Pinus</i>	<i>monophylla</i>	Torr. & Frem.	pinyon pine
Pinaceae	<i>Pinus</i>	<i>ponderosa</i>	Laws.	
Plantaginaceae	<i>Plantago</i>	<i>purshii</i> var. <i>oblonga</i>	R. & S. (Morris) Shinnars	
Poaceae	<i>Agropyron</i>	<i>cristatum</i>	(L.) Gaertn.	
Poaceae	<i>Agropyron</i>	<i>spicatum</i>	(Pursh) Scribn. & Smith	wheatgrass
Poaceae	<i>Agropyron</i>	<i>trachycaulum</i>	(Link) Malte	wheatgrass
Poaceae	<i>Agrostis</i>	<i>semiverticillata</i>	(Forsk.) C. Chr.	bentgrass
Poaceae	<i>Aristida</i>	<i>arizonica</i>	Vasey	three-awn
Poaceae	<i>Aristida</i>	<i>fendleriana</i>	Steud.	three-awn
Poaceae	<i>Bouteloua</i>	<i>curtipendula</i>	(Michx.) Torr.	side-oats grama
Poaceae	<i>Bromus</i>	<i>marginatus</i>	Nees	bromegrass
Poaceae	<i>Bromus</i>	<i>rubens</i>	L.	foxtail chess
Poaceae	<i>Bromus</i>	<i>tectorum</i>	L.	cheat grass
Poaceae	<i>Poa</i>	<i>pratensis</i>	L.	
Poaceae	<i>Setaria</i>	<i>macrostachya</i>	HBK.	bristle grass
Poaceae	<i>Stipa</i>	<i>comata</i>	Trin. & Rupr.	needle grass
Poaceae	<i>Trichachne</i>	<i>californica</i>	(Benth.) Chase	cotton-top
Poaceae	<i>Tridens</i>	<i>muticus</i>	(Torr.)	Nash

Polemoniaceae	<i>Gilia</i>	<i>longiflora</i>	(Torr.) G. Don	
Polemoniaceae	<i>Gilia</i>	<i>ophthalmoides</i>	Brand.	
Polemoniaceae	<i>Gilia</i>	<i>transmontana</i>	(Mason & A. Grant) A. & V. Grant	
Polemoniaceae	<i>Ipomopsis</i>	<i>aggregata ssp. aggregata</i>	(Pursh) V. Grant	skyrocket
Polemoniaceae	<i>Phlox</i>	<i>austromontana var. densa</i>	Cov. (Brand.) Wherry	phlox
Polemoniaceae	<i>Phlox</i>	<i>stansburyi</i>	(Torr.) Heller	phlox
Polemoniaceae	<i>Phlox</i>	<i>woodhousei</i>	(Gray) E. Nels.	phlox
Polygalaceae	<i>Polygala</i>	<i>subspinosa</i>	Wats.	
Polygonaceae	<i>Eriogonum</i>	<i>alatum</i>	Torr.	wild-buckwheat
Polygonaceae	<i>Eriogonum</i>	<i>deflexum</i>	Torr.	
Polygonaceae	<i>Eriogonum</i>	<i>heermannii</i>	Dur. & Hilg.	wild-buckwheat
Polygonaceae	<i>Eriogonum</i>	<i>jamesii</i>	Benth.	wild-buckwheat
Polygonaceae	<i>Eriogonum</i>	<i>pharnaceoides</i>	Torr. in Sitgr.	wild-buckwheat
Polygonaceae	<i>Eriogonum</i>	<i>racemosum</i>	Nutt.	wild-buckwheat
Polygonaceae	<i>Eriogonum</i>	<i>simpsoni</i>	Benth.	wild-buckwheat
Polygonaceae	<i>Eriogonum</i>	<i>umbellatum (aridum)</i>	Torr. (Stokes)	wild-buckwheat
Polygonaceae	<i>Polygonum</i>	<i>aviculare</i>	L.	knotweed
Polygonaceae	<i>Polygonum</i>	<i>sawatchense</i>	Small	knotweed
Portulacaceae	<i>Portulaca</i>	<i>oleraceae</i>	L.	purslane
Pteridaceae	<i>Cheilanthes</i>	<i>feeii</i>	T. Moore	lip fern
Pteridaceae	<i>Notholaena</i>	<i>cochisensis</i>	Goodd.	cloak fern
Pteridaceae	<i>Pellaea</i>	<i>truncata</i>	Goodd.	cliff-brake
Ranunculaceae	<i>Aquilegia</i>	<i>chrysantha</i>	Gray	columbine
Ranunculaceae	<i>Delphinium</i>	<i>nelsoni</i>	Greene	larkspur
Ranunculaceae	<i>Delphinium</i>	<i>scaposum</i>	Greene	larkspur
Ranunculaceae	<i>Ranunculus</i>	<i>testiculatus</i>	Crantz.	buttercup
Ranunculaceae	<i>Thalictrum</i>	<i>fendleri</i>	Engelm. ex Gray	meadow-rue
Rhamnaceae	<i>Ceanothus</i>	<i>greggi</i>	Gray	
Rosaceae	<i>Amelanchier</i>	<i>utahensis</i>	Koehne	service-berry

Rosaceae	<i>Chamaebatiaria</i>	<i>millefolium</i>	(Torr.) Maxim.	fern-bush
Rosaceae	<i>Coleogyne</i>	<i>ramosissima</i>	Torr.	blackbrush
Rosaceae	<i>Cowania</i>	<i>mexicana</i> var. <i>stansburiana</i>	D. Don (Torr.) Jeps.	cliff-rose
Rosaceae	<i>Fallugia</i>	<i>paradoxa</i>	(D. Don) Endl.	Apache-plume
Rosaceae	<i>Prunus</i>	<i>virginiana</i>	L.	choke-cherry
Rosaceae	<i>Rosa</i>	<i>stellata</i>	Wooton	
Rubiaceae	<i>Galium</i>	<i>wrightii</i>	Gray	bedstraw
Rutaceae	<i>Ptelea</i>	<i>pallida</i>	Greene	hop-tree
Santalaceae	<i>Comandra</i>	<i>umbellata</i>	(L.) Nutt.	bastard toad-flax
Saxifragaceae	<i>Heuchera</i>	<i>versicolor</i>	Greene	
Saxifragaceae	<i>Ribes</i>	<i>cereum</i>	Dougl.	currant
Scrophulariaceae	<i>Castilleja</i>	<i>chromosa</i>	A. Nels.	paint-brush
Scrophulariaceae	<i>Castilleja</i>	<i>linariaefolia</i>	Benth.	paint-brush
Scrophulariaceae	<i>Cordylanthus</i>	<i>parviflorus</i>	(Ferris) Wiggins	bird's-beak
Scrophulariaceae	<i>Penstemon</i>	<i>barbatus</i>	(Cav.) Roth.	beard-tongue
Scrophulariaceae	<i>Penstemon</i>	<i>bridgesii</i>	Gray	beard-tongue
Scrophulariaceae	<i>Penstemon</i>	<i>eatoni</i>	Gray	beard-tongue
Scrophulariaceae	<i>Penstemon</i>	<i>linarioides</i>	Gray	beard-tongue
Scrophulariaceae	<i>Penstemon</i>	<i>nudiflorus</i>	Gray	beard-tongue
Scrophulariaceae	<i>Penstemon</i>	<i>pachyphyllus</i> ssp. <i>congestus</i>	Gray (Jones) Keck	beard-tongue
Scrophulariaceae	<i>Penstemon</i>	<i>palmeri</i>	Gray	beard-tongue
Scrophulariaceae	<i>Penstemon</i>	<i>thompsoniae</i>	(Gray) Rydb.	beard-tongue
Solanaceae	<i>Nicotiana</i>	<i>attenuata</i>	Torr.	tobacco
Solanaceae	<i>Physalis</i>	<i>hederaefolia</i> var. <i>cordifolia</i>	Gray (Gray) Waterfall	ground-cherry
Solanaceae	<i>Solanum</i>	<i>triflorum</i>	Nutt.	nightshade
Verbenaceae	<i>Verbena</i>	<i>bracteata</i>	Lag. & Rodr.	verbena
Verbenaceae	<i>Verbena</i>	<i>gooddingii</i>	Briq.	verbena
Violaceae	<i>Viola</i>	<i>nuttallii</i>	Pursh	violet

Appendix 2: Birds of the Shivwits Plateau region (data from Huey 1939, Lake Mead National Recreation Area 1978, Blake 1981, Arizona Breeding Bird Atlas-ABBA, unpublished, and others)

Family	Genus	Species	Reference	Common Name
Ardeidae	<i>Ardea</i>	<i>herodias</i>	LMNRA	great blue heron
Anatidae	<i>Anas</i>	<i>crecca</i>	Blake	green-winged teal
Anatidae	<i>Oxyura</i>	<i>jamaicensis</i>	Blake	ruddy duck
Cathartidae	<i>Cathartes</i>	<i>aura</i>	LMNRA,ABBA	turkey vulture
Accipitridae	<i>Accipiter</i>	<i>striatus</i>	Blake	sharp-shinned hawk
Accipitridae	<i>Accipiter</i>	<i>cooperii</i>	Blake	Cooper's hawk
Accipitridae	<i>Accipiter</i>	<i>gentiles</i>	ABBA	northern goshawk
Accipitridae	<i>Buteo</i>	<i>jamaicensis</i>	Blake,ABBA	red-tailed hawk
Accipitridae	<i>Aquila</i>	<i>chrysaetos</i>	Blake	golden eagle
Falconidae	<i>Falco</i>	<i>peregrinus</i>	Austin	peregrine falcon
Falconidae	<i>Falco</i>	<i>sparverius</i>	Blake,ABBA	American kestrel
Charadriidae	<i>Charadrius</i>	<i>vociferous</i>	Blake	killdeer
Scolopacidae	<i>Actitis</i>	<i>macularia</i>	Blake	spotted sandpiper
Scolopacidae	<i>Limnodromus</i>	<i>scolopaceus</i>	Blake	long-billed dowitcher
Recurvirostridae	<i>Himantopus</i>	<i>mexicanus</i>	Blake	black-necked stilt
Phalaropodidae	<i>Steganopus</i>	<i>tricolor</i>	Blake	Wilson's phalarope
Laridae	<i>Larus</i>	<i>philadelphia</i>	Blake	Bonaparte's gull
Phasianidae	<i>Centrocercus</i>	<i>urophasianus</i>	Huey	sage grouse
Phasianidae	<i>Meleagris</i>	<i>gallopavo</i>	ABBA	wild turkey
Columbidae	<i>Columba</i>	<i>fasciata</i>	Blake,ABBA	band-tailed pigeon
Columbidae	<i>Zenaidura</i>	<i>macroura</i>	LMNRA,ABBA	mourning dove
Tytonidae	<i>Tyto</i>	<i>alba</i>	ABBA	barn owl
Strigidae	<i>Otus</i>	<i>flammeolus</i>	LMNRA,ABBA	flamulated owl
Strigidae	<i>Otus</i>	<i>asio</i>	Huey,ABBA	screech owl
Strigidae	<i>Bubo</i>	<i>virginianus</i>	Huey,ABBA	great horned owl
Strigidae	<i>Athene</i>	<i>cunicularia</i>	Huey	burrowing owl
Strigidae	<i>Asio</i>	<i>otus</i>	ABBA	long-eared owl
Caprimulgidae	<i>Phalaenoptilus</i>	<i>nuttallii</i>	Blake,ABBA	common poor-will
Caprimulgidae	<i>Chordeiles</i>	<i>minor</i>	Blake,ABBA	common nighthawk
Apodidae	<i>Chaetura</i>	<i>saxatalis</i>	Blake,ABBA	white-throated swift
Trochilidae	<i>Selasphorus</i>	<i>platycercus</i>	Blake,ABBA	broad-tailed hummingbird
Trochilidae	<i>Archilochus</i>	<i>alexandri</i>	ABBA	black-chinned hummingbird
Picidae	<i>Colaptes</i>	<i>auratus</i>	Huey, Blake,ABBA	northern flicker
Picidae	<i>Melanerpes</i>	<i>formicivorus</i>	Blake,ABBA	acorn woodpecker
Picidae	<i>Sphyrapicus</i>	<i>thyroideus</i>	Blake,ABBA	Williamson's sapsucker
Picidae	<i>Dendrocopos</i>	<i>villosus</i>	Huey, Blake,ABBA	hairy woodpecker
Tyrannidae	<i>Tyrannus</i>	<i>tyrannus</i>	Blake,ABBA	western kingbird
Tyrannidae	<i>Tyrannus</i>	<i>vociferans</i>	Blake,ABBA	Cassin's kingbird
Tyrannidae	<i>Myiarchus</i>	<i>cinerascens</i>	Blake,ABBA	ash-throated flycatcher
Tyrannidae	<i>Sayornis</i>	<i>nigricans</i>	Blake	black phoebe
Tyrannidae	<i>Sayornis</i>	<i>saya</i>	Blake,ABBA	Say's phoebe
Tyrannidae	<i>Empidonax</i>	<i>oberholseri</i>	Blake,ABBA	dusky flycatcher

Tyrannidae	<i>Empidonax</i>	<i>wrightii</i>	Blake, ABBA	gray flycatcher
Tyrannidae	<i>Empidonax</i>	<i>difficilis</i>	Huey, ABBA	western flycatcher
Tyrannidae	<i>Contopus</i>	<i>sordidulus</i>	Blake, ABBA	western wood pewee
Tyrannidae	<i>Contopus</i>	<i>borealis</i>	Huey, ABBA	olive-sided flycatcher
Alaudidae	<i>Eremophila</i>	<i>alpestris</i>	Blake	horned lark
Hirundinidae	<i>Tachycineta</i>	<i>thalassina</i>	Blake, ABBA	violet-green swallow
Hirundinidae	<i>Stelgidopteryx</i>	<i>ruficollis</i>	Blake	rough-winged swallow
Hirundinidae	<i>Progne</i>	<i>subis</i>	Huey	purple martin
Corvidae	<i>Cyanocitta</i>	<i>stelleri</i>	Huey, Blake, ABBA	Stellar's jay
Corvidae	<i>Aphelocoma</i>	<i>coerulescens</i>	Huey, Blake, ABBA	scrub jay
Corvidae	<i>Corvus</i>	<i>corax</i>	Huey, Blake, ABBA	common raven
Corvidae	<i>Gymnorhinus</i>	<i>cyanocephalus</i>	LMNRA, Blake, ABBA	pinon jay
Corvidae	<i>Nucifraga</i>	<i>columbiana</i>	ABBA	Clark's nutcracker
Paridae	<i>Parus</i>	<i>gambeli</i>	Blake, ABBA	mountain chickadee
Paridae	<i>Parus</i>	<i>inornatus</i>	LMNRA, Blake, ABBA	plain titmouse
Paridae	<i>Psaltriparus</i>	<i>minimus</i>	Blake, ABBA	common bushtit
Sittidae	<i>Sitta</i>	<i>carolinensis</i>	Huey, Blake, ABBA	white-breasted nuthatch
Sittidae	<i>Sitta</i>	<i>canadensis</i>	Blake, ABBA	red-breasted nuthatch
Sittidae	<i>Sitta</i>	<i>pygmaea</i>	Huey, Blake, ABBA	pygmy nuthatch
Certhiidae	<i>Certhia</i>	<i>familiaris</i>	Blake, ABBA	brown creeper
Troglodytidae	<i>Troglodytes</i>	<i>aedon</i>	Blake, ABBA	house wren
Troglodytidae	<i>Thryomanes</i>	<i>bewickii</i>	Blake, ABBA	Bewick's wren
Troglodytidae	<i>Salpinctes</i>	<i>obsoletus</i>	Blake, ABBA	rock wren
Troglodytidae	<i>Catherpes</i>	<i>mexicanus</i>	ABBA	canyon wren
Muscicapillidae	<i>Polioptila</i>	<i>caerulea</i>	ABBA, L. Stevens	Blue-gray gnatcatcher
Muscicapillidae	<i>Polioptila</i>	<i>melanura</i>	L. Stevens	Black-tailed gnatcatcher
Mimidae	<i>Mimus</i>	<i>polyglottos</i>	Huey, ABBA	northern mockingbird
Mimidae	<i>Orioscopes</i>	<i>montanus</i>	Blake	sage thrasher
Mimidae	<i>Toxostoma</i>	<i>crissale</i>	ABBA	crissal thrasher
Turdidae	<i>Turdus</i>	<i>migratorius</i>	Blake, ABBA	American robin
Turdidae	<i>Sialia</i>	<i>mexicana</i>	Blake, ABBA	western bluebird
Turdidae	<i>Sialia</i>	<i>currucoides</i>	Blake	mountain bluebird
Turdidae	<i>Myadestes</i>	<i>townsendi</i>	Blake, ABBA	Townsend's solitaire
Turdidae	<i>Catharus</i>	<i>guttatus</i>	ABBA	hermit thrush
Sylviidae	<i>Polioptila</i>	<i>caerulea</i>	Blake	blue-gray gnatcatcher
Sylviidae	<i>Regulus</i>	<i>calendula</i>	Blake	ruby-crowned kinglet
Motacillidae	<i>Anthus</i>	<i>spinoletta</i>	Blake	water pipit
Ptilogonatidae	<i>Phainopepla</i>	<i>nitens</i>	ABBA	phainopepla
Laniidae	<i>Lanius</i>	<i>ludovicianus</i>	Blake	loggerhead shrike
Vireonidae	<i>Vireo</i>	<i>vicinior</i>	Blake, ABBA	gray vireo
Vireonidae	<i>Vireo</i>	<i>solitarius</i>	Blake, ABBA	solitary vireo
Vireonidae	<i>Vireo</i>	<i>gilvus</i>	Blake, ABBA	warbling vireo
Parulidae	<i>Vermivora</i>	<i>virginiae</i>	Blake, ABBA	Virginia's warbler
Parulidae	<i>Dendroica</i>	<i>coronata</i>	Blake, ABBA	yellow-rumped warbler
Parulidae	<i>Dendroica</i>	<i>nigrescens</i>	Blake, ABBA	black-throated gray warbler

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Parulidae	<i>Dendroica</i>	<i>graciae</i>	Blake, ABBA	Grace's warbler
Parulidae	<i>Oporornis</i>	<i>tolmiei</i>	Blake, ABBA	MacGillivray's warbler
Parulidae	<i>Wilsonia</i>	<i>pusilla</i>	Blake, ABBA	Wilson's warbler
Icteridae	<i>Sturnella</i>	<i>neglecta</i>	Blake, ABBA	western meadowlark
Icteridae	<i>Icterus</i>	<i>parisorum</i>	Blake, ABBA, K. Burke	Scott's oriole
Icteridae	<i>Icterus</i>	<i>bullocki</i>	Blake	northern oriole
Icteridae	<i>Euphagus</i>	<i>cyaniceps</i>	Blake	Brewer's blackbird
Icteridae	<i>Molothrus</i>	<i>Ater</i>	Blake, ABBA	brown-headed cowbird
Thraupidae	<i>Piranga</i>	<i>flava</i>	Blake, ABBA	hepatic tanager
Thraupidae	<i>Piranga</i>	<i>rubra</i>	ABBA	summer tanager
Thraupidae	<i>Piranga</i>	<i>ludoviciana</i>	Huey, ABBA	western tanager
Fringillidae	<i>Pheucticus</i>	<i>melanocephalus</i>	Blake, ABBA	black-headed grosbeak
Fringillidae	<i>Pheucticus</i>	<i>ludovicianus</i>	ABBA	rose-breasted grosbeak
Fringillidae	<i>Loxia</i>	<i>curvirostra</i>	Huey, ABBA	red crossbill
Fringillidae	<i>Carpodacus</i>	<i>cassinii</i>	Blake, ABBA	Cassin's finch
Fringillidae	<i>Carpodacus</i>	<i>mexicanus</i>	Blake, ABBA	house finch
Fringillidae	<i>Carduelis</i>	<i>Pinus</i>	Blake	pine siskin
Fringillidae	<i>Carduelis</i>	<i>psaltria</i>	Blake, ABBA	lesser goldfinch
Fringillidae	<i>Pipilo</i>	<i>chlorura</i>	Huey, Blake	green-tailed towhee
Fringillidae	<i>Pipilo</i>	<i>erythrophthalmus</i>	Blake, ABBA	rufous-sided towhee
Fringillidae	<i>Passerculus</i>	<i>sandwichensis</i>	Blake	savannah sparrow
Fringillidae	<i>Pooecetes</i>	<i>gramineus</i>	Blake	vesper sparrow
Fringillidae	<i>Chondestes</i>	<i>grammacus</i>	Blake, ABBA	lark sparrow
Fringillidae	<i>Amphispiza</i>	<i>bilineata</i>	Huey, ABBA	black-throated sparrow
Fringillidae	<i>Junco</i>	<i>hyemalis</i>	Blake, ABBA	dark-eyed junco
Fringillidae	<i>Spizella</i>	<i>passerina</i>	Blake	chipping sparrow
Fringillidae	<i>Spizella</i>	<i>breweri</i>	Blake, ABBA	Brewer's sparrow
Fringillidae	<i>Spizella</i>	<i>atrogularis</i>	Blake, ABBA	black-chinned sparrow
Fringillidae	<i>Zonotrichia</i>	<i>leucophrys</i>	Blake	white-crowned sparrow

APPENDIX 3: Mammals of the Shivwits Plateau.

FAMILY	GENUS	SPECIES	SUBSPECIES	AUTHOR	COMMONNAME
BATS					
Phyllostomidae	<i>Macrotus</i>	<i>californicus</i>		Baird	California leaf-nosed bat
Vespertilionidae	<i>Myotis</i>	<i>volans</i>	<i>interior</i>	Miller, Miller and Allen	Long-legged myotis
Vespertilionidae	<i>Myotis</i>	<i>leibii</i>	<i>melanorhinus</i>	Merriam, Miller and Allen, Glass and Baker	Small-footed myotis
Vespertilionidae	<i>Myotis</i>	<i>thysanodes</i>	<i>thysanodes</i>	Miller	Fringed myotis
Vespertilionidae	<i>Myotis</i>	<i>californicus</i>	<i>stephensi</i>	Dalquest	California myotis
Vespertilionidae	<i>Pipistrellus</i>	<i>hesperus</i>	<i>hesperus</i>	Allen, Miller	Western pipistrelle
Vespertilionidae	<i>Eptesicus</i>	<i>fuscus</i>	<i>pallidus</i>	Young, Miller	Big brown bat
Vespertilionidae	<i>Lasiurus</i>	<i>cinereus</i>	<i>cinereus</i>	Palisot de Beauvois, H. Allen	Hoary bat
Vespertilionidae	<i>Lasionycteris</i>	<i>noctivagans</i>		Le Conte, H. Allen	Silver-haired bats
Molossidae	<i>Tadarida</i>	<i>brasiliensis</i>	<i>mexicana</i>	Saussure, Schwartz, Merriam	Free-tailed bat
RABBITS					
Leporidae	<i>Sylvilagus</i>	<i>audubonii</i>	<i>arizonae</i>	J. A. Allen, Nelson,	Desert cottontail
Leporidae	<i>Lepus</i>	<i>californicus</i>	<i>deserticola</i>	Mearns, Nelson, Hall and Whitlow	Black-tailed jack rabbit
RODENTS					
Sciuridae	<i>Tamias</i>	<i>dorsalis</i>	<i>grinnelli</i>	Burt	Cliff chipmunk
Sciuridae	<i>Ammospermophilus</i>	<i>leucurus</i>	<i>leucurus</i>	Merriam, Mearns	White-tailed antelope squirrel
Sciuridae	<i>Spermophilus</i>	<i>variegates</i>	<i>grammurus</i>	Say, Hall and Kelson	Rock squirrel
Geomyidae	<i>Thomomys</i>	<i>bottae</i>	<i>planirostris</i>	Burt, Hall and Davis, Goldman, Durham	Botta's pocket gopher
Heteromyidae	<i>Perognathus</i>	<i>longimembris</i>	<i>arizonensis</i>	Goldman, Heuy	Little pocket mouse
Heteromyidae	<i>Perognathus</i>	<i>formosus</i>	<i>formosus</i>	Merriam, Cockrum,	Long-tailed pocket mouse
Heteromyidae	<i>Perognathus</i>	<i>parvus</i>	<i>trumbullensis</i>		Hispid pocket mouse
Heteromyidae	<i>Perognathus</i>	<i>penicillatus</i>	<i>sobrinus</i>	Goldman	Desert pocket mouse
Heteromyidae	<i>Dipodomys</i>	<i>ordii</i>	<i>cupidineus</i>	Goldman	Kangaroo rat
Heteromyidae	<i>Dipodomys</i>	<i>merriami</i>	<i>merriami</i>	Mearns	Merriam's Kangaroo rat
Heteromyidae	<i>Dipodomys</i>	<i>merriami</i>	<i>frenatus</i>	Bole	Merriam's Kangaroo rat
Heteromyidae	<i>Dipodomys</i>	<i>merriami</i>	<i>vulcani</i>	Benson	Merriam's Kangaroo rat
Heteromyidae	<i>Dipodomys</i>	<i>deserti</i>	<i>deserti</i>	Stephens, Elliot	Desert kangaroo rat
Heteromyidae	<i>Dipodomys</i>	<i>mMicrops</i>	<i>celsus</i>	Goldman	Chisel-toothed kangaroo rat
Muridae	<i>Reithrodontomys</i>	<i>megalotis</i>	<i>megalotis</i>	Baird, Allen, J. A. Allen	Western harvest mouse
Muridae	<i>Peromyscus</i>	<i>eremicus</i>	<i>eremicus</i>	Baird, Allen, Blossom	Cactus mouse
Muridae	<i>Peromyscus</i>	<i>crinitus</i>	<i>pergracilis</i>	Goldman	Canyon mouse
Muridae	<i>Peromyscus</i>	<i>maniculatus</i>	<i>sonoriensis</i>	LeConte, Osgood, Merriam	Deer mouse
Muridae	<i>Peromyscus</i>	<i>boylii</i>	<i>rowleyi</i>	Allen, Mearns	Brush mouse

Muridae	<i>Peromyscus</i>	<i>truei</i>	<i>truei</i>	Shufeldt, Thomas, Merriam, Elliot	Pinyon mouse
Muridae	<i>Onychomys</i>	<i>leucogaster</i>	<i>melanophrys</i>	Merriam	Northern grasshopper mouse
Muridae	<i>Onychomys</i>	<i>torridus</i>	<i>longicaudus</i>	Merriam	Southern grasshopper mouse
Muridae	<i>Neotoma</i>	<i>lepida</i>	<i>devia</i>	Goldman	Desert wood rat
Muridae	<i>Mus</i>	<i>musculus</i>		Linnaeus	House mouse
PORCUPINE					
Erethizontidae	<i>Erethizon</i>	<i>dorsatum</i>	<i>couesi</i>	Mearns	
WEASLES					
Mustelidae	<i>Lutra</i>	<i>canadensis</i>	<i>sonora</i>	Rhodes, Allen	River otter
BEARS					
Ursidae	<i>Ursus</i>	<i>arctos</i>	<i>horribilis</i>	Ord, Rausch, Merriam	Grizzly bear
RACCOONS					
Procyonidae	<i>Procyon</i>	<i>lotor</i>	<i>pallidus</i>	Merriam, Grinnell, Mearns	Raccoon
Procyonidae	<i>Bassariscus</i>	<i>astutus</i>	<i>nevadensis</i>	Miller	Ringtail
DOGS					
Canidae	<i>Canis</i>	<i>latrans</i>	<i>mearnsi</i>	Merriam, Nelson	Coyote
Canidae	<i>Canis</i>	<i>lupus</i>	<i>youngi</i>	Goldman	Gray wolf
Canidae	<i>Vulpes</i>	<i>macrotis</i>	<i>macrotis</i>	Merriam, Goldman, Elliot, Nelson and Goldman	Kit fox
CATS					
Felidae	<i>Felis</i>	<i>rufus</i>	<i>baileyi</i>	Merriam	Bobcat
Felidae	<i>Puma</i>	<i>concolor</i>	<i>kaibabensis</i>	Nelson and Goldman	Mountain lion
UNGULATES					
Cervidae	<i>Odocoileus</i>	<i>hemionus</i>	<i>hemionus</i>	Rafinesque	Mule deer
Ovidae	<i>Ovis</i>	<i>canadensis</i>		LAME 1979	
Collared Peccary	<i>Pecari</i>	<i>angulatus</i>		Stevens 1992	