Fossil Creek
State of the Watershed Report

Photo by Nick Berezenko, courtesy of APS

Current Condition of the Fossil Creek Watershed Prior to Return of Full Flows and other Decommissioning Activities

Northern Arizona University
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The *Fossil Creek State of the Watershed Report* is dedicated to the memory of Mark Whitney, Coconino National Forest Fishery Biologist, and Elizabeth Matthews, Forest Service Geologist, Northern Arizona Zone.

Comments and feedback to this report are welcome.
Please direct correspondence to:

Aquatic Species and Habitat (fish, macroinvertebrates, crayfish, leaf litter)
Dr. Jane Marks (Jane.Marks@nau.edu) (928-523-0918)
Recreation and Visitor Use
Dr. Marty Lee (Martha.Lee@nau.edu) (928-523-6644)
Spring Characterization, Groundwater, and Water Quality
Dr. Abe Springer (Abe. Springer@nau.edu) (928-523-7198)
Sediment, Stream Classification, Hydrology
Dr. Charlie Schlinger (Charles.Schlinger@nau.edu) (928-523-0652)
Terrestrial Species
Michele James (Michele.James@nau.edu)

Contributing authors (in order of first appearance in report)

Michele James, Fossil Creek Project Coordinator, College of Engineering and Natural Sciences, Northern Arizona University, Flagstaff, Arizona

Grant Loomis, Forest Hydrologist, Tonto National Forest, Phoenix, Arizona

Charles Schlinger, Engineer, College of Engineering and Natural Sciences, Northern Arizona University, Flagstaff, Arizona

Lorrie Yazzie, Master's Degree Student, College of Engineering and Natural Sciences, Northern Arizona University, Flagstaff, Arizona

Abe Springer, Hydrogeologist, Department of Geology, Northern Arizona University, Flagstaff, Arizona

Rory Steinke, Watershed Program Manager, Coconino National Forest, Flagstaff, Arizona

Daniela Roth, Botantist, Northern Arizona University, Flagstaff, Arizona

Mark Whitney, Fishery Biologist, Coconino National Forest, Flagstaff, Arizona

Allen Haden, Research Specialist, Department of Biological Sciences, Northern Arizona University, Flagstaff, Arizona

Jane Marks, Biologist, Department of Biological Sciences, Northern Arizona University, Flagstaff, Arizona

Eric Dinger, Graduate Research Assistant, Ph.D. Student, Department of Biological Sciences, Northern Arizona University, Flagstaff, Arizona

Carri LeRoy, Graduate Research Assistant, Ph.D. Student, Department of Biological Sciences, Northern Arizona University, Flagstaff, Arizona

Cody Carter, Master's Degree Student, Department of Biological Sciences, Northern Arizona University, Flagstaff, Arizona

Ken Adams, Graduate Research Assistant, Master's Degree Student, Department of Biological Sciences, Northern Arizona University, Flagstaff, Arizona

Janie Agyagos, Wildlife Biologist, Coconino National Forest, Red Rock Ranger District, Sedona, Arizona

Shaula Hedwall, Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, Flagstaff Suboffice, Flagstaff, Arizona

Sharynn-Marie Blood, District Archeologist, Coconino National Forest, Red Rock Ranger District, Sedona, Arizona

Scott Wood, Forest Archeologist, Tonto National Forest, Phoenix, Arizona

Christopher Coder, Tribal Archaeologist, Yavapai Apache Nation

Vincent Randall, Apache Historian/Tribal Council, Yavapai Apache Nation

Martha Lee, Wildland Recreation Specialist, School of Forestry, Northern Arizona University, Flagstaff, Arizona

Matthew Jedra, Masters Student, School of Forestry, Northern Arizona University, Flagstaff, Arizona

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Executive Summary

The Fossil Creek State of the Watershed Report summarizes available information on the current conditions of the physical, biological, and social environment of the Fossil Creek Watershed (see Figure 5) prior to the start of the Arizona Public Service Company (APS) Childs-Irving decommissioning activities which began in spring 2005. While this report is a summary of the current watershed conditions, some of the information provided by individual authors is specific to and focused primarily on Fossil Creek or the riparian corridor.

This report addressesses the physical and biological features of the Fossil Creek Watershed as the human and social environment. Below is a summary of the main points of each topic discussed in detail within this report.

Fossil Creek and its History

Background

- Fossil Creek is a major tributary of the Verde River and is located within the incised canyons of the Mogollon Rim country of central Arizona.
- Fossil Creek is located nearly entirely (with the exception of approximately 20-acres of private parcels) on lands under the jurisdiction of the USDA Forest Service and forms the boundary between the Coconino and Tonto National Forests and between Gila and Yavapai Counties. Fossil Creek flows through the Fossil Springs and Mazatzal Wilderness areas.
- Fossil Springs represents the largest concentration of spring-water discharge in the Mogollon Rim region. Spring flows emerge over approximately a 1,000-foot reach of Fossil Creek and flow is relatively constant at nearly 46 cubic feet per second (cfs).
- The major human land uses within the Fossil Creek Watershed are recreation, livestock grazing, and until June 18, 2005, hydroelectric power production.
- Fossil Creek supports an abundant and diverse native fish community. A native fish restoration project completed in the fall of 2004 removed non-native fish in an attempt to restore a native fishery to all but the lower five miles of Fossil Creek.

Travertine

- The base flow of Fossil Creek is supplied by water discharged from Fossil Springs which contains high concentrations of calcium carbonate and dissolved carbon dioxide, leading to the formation of travertine. Rich in calcium carbonate, travertine precipitates and deposits on the bed and bank of the channel and on rocks, leaves, and other objects in the channel.
- Encrustation of these features by travertine, forming "fossils", is the basis for the origin of the creek's name.
- The travertine deposition forms dams and deep pools behind these dams, creating a series of steps and pools. Deposition rates of almost one foot per month were

recorded on Fossil Creek in March 1996 when the Irving Power Plant was shut down for maintenance.
- Since the beginning of the diversion of most of the Fossil Creek baseflow to the Irving and Childs power plants which began nearly 100 years ago, much of the pre-existing travertine has deteriorated.

Hydroelectric Generation: Childs-Irving Power Plants
- The Childs Power Plant was constructed in 1909 and most of the flow of Fossil Creek was diverted at the current Irving Power Plant site into a series of flumes, siphons, penstocks, turbines, and a reservoir (Stehr Lake).
- The Irving Power Plant was constructed and came on line in 1916 to meet the increasing demands for power in Yavapai County.
- Childs-Irving project facilities begin at the Fossil Springs Diversion Dam, a 25-foot high concrete structure located approximately 0.2 miles below the lowermost spring of the Fossil Springs complex. The dam diverts almost the entire discharge of Fossil Springs.
- To ensure an adequate, continuous supply of water to the Childs plant, Stehr Lake was built in an old dry lakebed located on a natural bench above Fossil Creek. Originally, Stehr Lake had a surface area of nearly 23 acres, although in recent years open water has covered only 3-4 acres due to sedimentation and vegetative infilling.

Decommissioning of Childs-Irving
- The Federal Power Commission issued a license for a period of 50 years on January 1, 1945 for the Childs-Irving power plants. In 1992, APS filed an application for a new license for the power plants.
- APS then entered into discussions with the Forest Service, US Fish and Wildlife Service, and environmental interveners and in 2000, APS and the other parties filed an Offer of Settlement (Settlement Agreement) requesting that the Federal Energy Regulatory Commission (FERC) approve the surrender of the license to operate the hydroelectric facility and proposed to remove facilities and restore the area.
- The Settlement Agreement stated that APS would cease power generation and restore full flows to Fossil Creek no later than December 31, 2004 and complete site restoration by December 31, 2009.
- Full flows were returned to Fossil Creek on June 18, 2005.

Physical and Biological Environment

Climate
- The Fossil Creek watershed is located in a semi-arid climatic region, although temperature, vegetation, and precipitation very greatly depending on elevation. Average daily temperatures range from 8.3 to 27.2 degrees C at Childs.
- This watershed is located on the edge of the Mogollon Rim; this escarpment can give rise to large storms due to the orographic effect. Average annual

precipitation on the Fossil Creek watershed ranges from 25 inches on the Mogollon Rim to 18 inches at Childs on the Verde River.

Soils

- Available soils information is developed from a summary of soil condition using Terrestrial Ecosystem Survey (TES) data for a 36,225-acre Forest Service-defined area called the Fossil Creek Planning area (see Figure 5).
- 8 percent of the planning area contains soils rated as unsatisfactory. Most identified unsatisfactory soils result from high levels of historic grazing and continued grazing probably beyond the carrying capacity of the land.
- 49 percent of the planning area has soils that are rated satisfactory-inherently unstable where, although functioning properly and normally, the soil is eroding faster than it is renewing itself. Almost all acreage in this class occurs on slopes greater than 40 percent within the central and western portions of the planning area.
- Areas where grazing has historically occurred and has continued, and areas where access is favorable to dispersed camping and recreation tend to exhibit reduced vegetation ground cover and soil degradation.
- The physical and biological conditions of the soil system are at risk, or will not support additional disturbance.

Water

Watershed Hydrology, Watershed and Channel Conditions, & Water Rights

- Continuous stream flow guage data are unavailable for Fossil Creek.
- The Fossil Springs provide approximately 74 percent of the average annual basin yield above the Fossil Springs Diversion Dam.
- The contribution of watershed runoff, generally snowmelt or precipitation from frontal storms, to stream flow varies considerably from winter/early spring to summer.
- Reduced runoff in the summer can be attributed to the high air temperatures and associated high rates of evapotranspiration that are common to this area in Central Arizona.
- The Fossil Creek watershed condition suffered greatly from overgrazing into the early 20th century due to excessive runoff, erosion, and loss of riparian habitat.
- Sedimentation behind the dam, with an estimated volume of 25,000 cubic yards, has created a large flood plain.
- APS has held since 1900, a statement of claim of rights to use public waters of the state of Arizona on Fossil Creek. In addition, there are several other water rights and claims involving Fossil Creek due to it being a tributary to the Verde River. As described in the decommissioning settlement agreement, APS will transfer their water rights to the USDA Forest Service.
- As part of the license surrender, the Fossil Creek Diversion Dam crest will be lowered by at least 14 feet, with anticipated action in 2007. Once the crest is lowered, a significant portion, probably in excess of 50 percent, of the nearly 25,000 cubic yards of sediment presently stored behind the dam will be able to move downstream in response to storm flows.

Spring Characterization and Groundwater

- Fossil Springs is one of the few remaining unmanipulated major springs left in the West, and provides insight into the natural function of a critical keystone ecosystem.
- Fossil Springs has a discharge which is greater than any spring complex outside the tributaries to the Colorado River in Grand Canyon.
- There is estimated to be over 60 individual spring orifices of Fossil Springs.
- Critical to monitoring the baseflow of the springs in Fossil Creek is the establishment of a gauging station on Fossil Creek downstream of the springs.

Water Quality

- Water discharging from Fossil Springs is a Calcium-Bicarbonate type water.
- Preliminary examination indicates CO_2 is being released as the springs mix with atmospheric gases.
- Baseline monitoring is recommended to detect any changes in water chemistry. Long-term monitoring of spring discharge and water quality will assist in determining if there are any important changes in the rates of travertine formation.

Vegetation

- There are eight biotic communities documented in the Fossil Creek-Lower Verde River 5th Code Watershed.
- Within the smaller Fossil Creek Planning Area boundary, 314 species of flowering plants and ferns from 77 families have been documented.
- The 50-acre Fossil Springs Botanical Area is located above the Fossil Springs Diversion Dam. A total of 166 plant species have been recorded.
- The riparian zone along Fossil Creek is dominated by deciduous trees.
- Potential habitat is present within the Fossil Creek Planning Area for six sensitive or listed plants.
- Forty-two exotic/noxious weeds have been identified in the Fossil Creek Planning Area although no formal inventories have been conducted in the larger watershed area.

Aquatic Habitat and Fish

Aquatic Habitat and the Fisheries Resource

- The variation in fish species composition in Fossil Creek is a function of the change in habitat conditions, the influence of the Verde River fishery, both natural and man-made barriers, and introductions of non-native fish above these barriers.
- Above the diversion dam, the aquatic conditions are a combination of cobble/small boulder riffles, shallow runs, and moderately deep pools.
- Natural barriers near the Irving Power Plant have kept non-native fish species from traveling further upstream.
- The aquatic habitat in the stretch between the diversion dam and a little past the Irving Power Plant are characterized with runs, riffles, and moderately deep pools.

- Remnants of large travertine pools can be observed along the banks of this stretch while small travertine formations can be observed.
- A little below the Forest Road 708 bridge, travertine formations are no longer as evident. The aquatic habitat is mainly runs, riffles, and moderately deep pools.

Fish

- Fossil Creek provides an opportunity to preserve native fish because it is one of the few streams in Arizona retaining viable populations of six native fish species including headwater chub, roundtail chub, speckled dace, longfin dace, desert sucker, and Sonora sucker.
- Non-native fish have been one of the greatest threats to native fish in Fossil Creek. In the fall of 2004, an intensive multi-agency native fish restoration effort removed non-native fish from the upper 9 km of Fossil Creek and constructed a fish barrier on the lower end of Fossil Creek, upstream of the confluence with the Verde River.
- Two potential threats remain to native fish following the restoration: 1) exotic crayfish; and, 2) the release of sediments trapped behind the diversion dam.
- There is a critical need for monitoring of non-native fish following the native fish restoration project to determine if the constructed fish barrier effectively prevents upstream migration of non-native fish and to assess whether non-native fish are being transplanted by humans back into Fossil Creek above the barrier.

Special Status Fish Species' Natural History and Occurrence

- This section gives life history and distribution information on the following threatened, endangered, and sensitive species existing and potentially existing in the Fossil Creek Watershed: roundtail chub, headwater chub, longfin dace, desert sucker, Sonora sucker, speckled dace, Colorado pikeminnow, razorback sucker, Gila topminnow, loach minnow, and spikedace.

Macroinvertebrates

- Aquatic macroinvertebrates, a diverse group of organisms comprising primarily insects, snails and worms, are important for transferring energy and nutrients contained in algae and leaf litter to higher trophic levels.
- The diversity of macroinvertebrates in Fossil Creek is high compared to other southwestern streams; to date, 147 macroinvertebrate species have been collected, including the endemic Fossil springsnail.
- Fossil Creek is thought to contain a high diversity of macroinvertabrates because 1) the springs at Fossil Creek have remained relatively pristine, with full flows and no exotic species, presumably due to the barrier created by the diversion dam and, 2) travertine deposition in Fossil Creek promotes diversity because travertine areas are characterized by unique insects.
- During the fish restoration project, the piscicide used was harmful to macroinvertebrates, causing increased numbers in the drift samples, an indication of mortality and stress. The Fossil springsnail and the Page caddisfly are concentrated above the diversion dam and were not affected by the piscicide treatment.

- Aquatic macroinvertebrates are necessary for the recovery of native fish because ongoing stable isotope studies indicate that macroinvertebrates are a key food resource for native fish.

Leaf Litter Decomposition

- Leaf litter provides large quantities of energy to aquatic ecosystems.
- The energy provided by leaf litter inputs is important for the production of stream invertebrates and is transferred up the trophic chain to fish and riparian predators whith often depend on aquatic insects during some part of their life cycle.
- Studies undertaken to date at Fossil Creek indicate that leaf litter decomposition rates for both Arizona alder and Freemont cottonwood are faster above the diversion dam than directly below the dam. It has also been found that leaf litter decomposes more quickly in an active travertine deposition reach than in a non-travertine reach.
- Restoration of full flows to Fossil Creek is expected to result in overall higher decomposition, and the associated increase in available habitat will also likely increase macroinvertebrate production, providing more prey items for predatory fishes and birds along Fossil Creek.

Crayfish

- Arizona has no native crayfish, but two exotic crayfish species were introduced in Arizona in the 1970s. Crayfish have been observed in Fossil Creek since the 1990s.
- Crayfish in Fossil Creek eat a wide range of food including leaf litter, algae, and macroinvertebrates, with a preference toward macroinvertebrates, a primary food source of fish. This indicates that the crayfish have the potential to compete with native fish populations for food.
- Crayfish were not harmed by the piscicide used during the native fish restoration project. The only currently available way of removing crayfish is through manual trapping and netting.

Terrestrial Species

- The Fossil Creek Watershed supports over 175 known species of mammals, birds, reptiles, amphibians, and terrestrial invertebrates. There are many more species that potentially, and likely, occur in the watershed but have not yet been documented.
- The Fossil Creek watershed contains habitat for five federally listed species (bald eagle, Mexican spotted owl, southwestern willow flycatcher, Yuma clapper rail, and western yellow-billed cuckoo). In addition, the area provides habitat for state and federal sensitive species: 6 mammals; 4 birds; 2 amphibians; 3 reptiles; 1 snail; 14 invertebrates; and 10 Management Indicator Species (MIS).
- This section provides life history and distribution information on the federally listed and sensitive terrestrial species known to be present, or with habitat, in the Fossil Creek watershed. It also provides specific restoration goals and inventory and monitoring recommendations for these terrestrial species.

- Recreation impacts are a concern in relation to several listed and sensitive species because of the disturbance to breeding/nesting areas, especially along the Fossil Creek riparian area.

Humans and the Social Environment

Cultural and Archeological Resources

- The Fossil Creek watershed contains prehistoric and historic archaeological sites and historic structures.
- Archaeological surveys have been conducted in the Fossil Creek drainage and adjacent areas since 1890 and have continued periodically since then.
- The Child's-Irving hydroelectric power project is listed on the National Register of Historic Places and is recognized as the 11th National Historical Mechanical Engineering Landmark.
- The Fossil Creek watershed may contain sites of human use and occupation from as long ago as 8,000 to 10,000 years.
- It contains a number of historic sites reflecting use by Yavapai and Apache hunters, gatherers, and farmers and by stockmen who raised or drove cattle and sheep throughout the area.
- A majority of the features are prehistoric in date and consist most frequently of collapsed stone masonry structures, stone-built water control devices, pit ovens, and petroglyphs.
- Less than 3% of the cultural resources within the Fossil Creek watershed have been inventoried to current standards.
- All of the inventoried sites are currently considered eligible for the National Register of Historic Places, pending further evaluation.
- Vandalism and looting are primary causes of impacts to the historic and cultural resources in the Fossil Creek watershed.

The Yavapai-Apache Nation's Ancestral Ties to Fossil Creek

- This section provides an overview of the cultural ties of the Yavapai-Apache Nation to Fossil Creek.
- The Tonto Apache or Dilzhe'e People lived throughout the length of the Fossil Creek Canyon for centuries and called it Tu Do Tliz, the Blue Water Place.
- Today, based on trips into Fossil Creek with tribal elders, the Yavapai-Apache know of dozens of Apache places. However, there is little evidence remaining on the surface in these places because much of it was perishable being made from bone, wood, sinew, buckskin, rawhide, hair or plant fibers.

Recreation

- Recreation opportunities in Fossil Creek consist primarily of camping, swimming, and hiking.
- There are two established trail systems to Fossil Springs that are each approximately four miles in length and receive the most use in the late spring and summer months.

- Visitor surveys indicate that weekday use is predominately by visitors from the surrounding communities of Strawberry, Pine, and Camp Verde while weekend use attracted many visitors from Phoenix, Flagstaff, and other communities.
- A 2004 visitor survey found that 71 percent of visitors access Fossil Creek from the town of Strawberry via Forest Road 708.
- This survey found that 52% of Fossil Creek use occurs between Irving Power Plant and the Fossil Springs Diversion Dam.
- An inventory of 211 dispersed campsites in the Fossil Creek was conducted to evaluate the amount of impact such sites are having on the surrounding environment. Results indicated that of the 211 campsites, 85 were rated as low impact, 120 were rated as moderately impacted, and 6 were highly impacted. Indicators of impact included size and number of fire rings, vegetation loss, and the amount of toilet paper at each site.

Grazing in the Fossil Creek Watershed

- There are currently seven allotments that fall partially within the Fossil Creek watershed; these allotments are located on both the Coconino and Tonto National Forests.
- The four allotments on the Coconino National Forest are year-round allotments with three zones (winter, transition, summer). All are currently being grazed.
- Two of the three allotments on the Tonto National Forest are in a non-use status while the other is actively being used.
- A table in this section summarizes available information for these allotments including the number of livestock permitted, the grazing system, the vegetation type, range condition and trend, and soil condition.

What's Next: Research and Monitoring at Fossil Creek

- This section summarizes planned and desired research and monitoring as discussed in each section of the State of the Watershed Report.

Introduction

This report summarizes the current information available regarding the Fossil Creek Watershed located in central Arizona (Figure 1). It has been compiled in advance of the Arizona Public Service Company (hereafter referred to as APS) Childs-Irving decommissioning activities scheduled for 2005 – 2009. The decommissioning activities include the return of full flows to Fossil Creek, removal of most of the infrastructure associated with the Childs and Irving power plants including the flume, and the lowering of the Fossil Springs Diversion Dam.

This report summarizes the information available at the time of writing about the physical and biological environment as well as the social and human environment within the Fossil Creek Watershed (Figure 3). Within this watershed, the Report focuses primarily on Fossil Creek; the uplands are addressed only to a limited extent. This report is primarily intended to serve as an information source for those involved and interested in the current and future management of the Fossil Creek Watershed, including governmental agencies, conservation organizations, and citizens. Our goal in compiling this report has been to create a baseline condition report that can be used as a basis for tracking changes to the environment that may occur within the watershed in the future. This information could be used to develop a comprehensive watershed management plan in the future and/or to assist the Forest Service in determining appropriate management of the watershed. As new information becomes available as a result of on-going research and monitoring within the watershed, this report will become outdated and will no longer function as a current state of the watershed report. However, the digital and public nature of this report allows it to be updated by NAU or others in the future.

The various sections in this report utilize either English or metric figures. Please refer to Appendix D for a metric to English conversion table.

Fossil Creek and its History

Michele A. James, Grant Loomis, and Charles Schlinger

Background

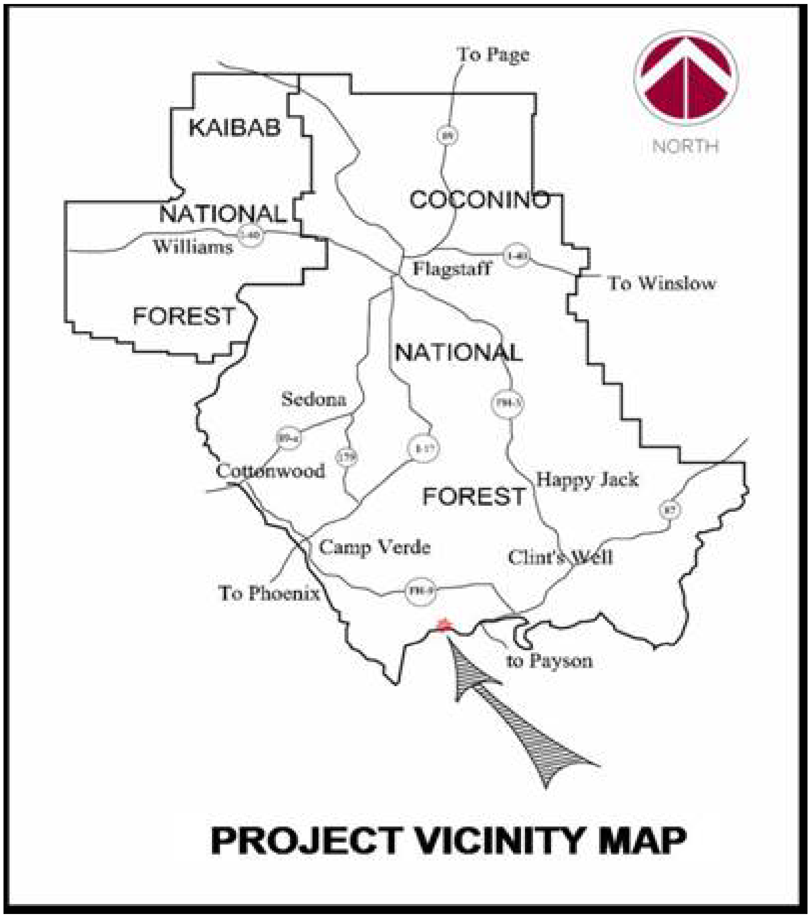
Fossil Creek is a major perennial tributary of the Verde River. It is located within the incised canyons of the Mogollon Rim[1] country in central Arizona (Figure 1) at elevations of 7260 feet along the Mogollon Rim to 2550 feet at the Verde River confluence. Fossil Creek begins about four miles northwest of the village of Strawberry at the convergence of Sandrock Canyon and Calf Pen Canyon just below the edge of the Mogollon Rim. The creek flows in a southwesterly direction for approximately 17 miles before entering the Verde River.

Fossil Creek is located nearly entirely on lands under the jurisdiction of the USDA Forest Service and forms the boundary between the Coconino and Tonto National Forests and between Gila and Yavapai Counties; Coconino National Forest and Yavapai County are located to the north of Fossil Creek, and the Tonto National Forest and Gila County are located to the south.

Fossil Creek flows partly through two wilderness areas. The creek lies within the Fossil Springs Wilderness Area from the confluence of Sand Tank and Calf Pen Canyons until Fossil Springs, and within the Mazatzal Wilderness from a short distance below the confluence with Sally May Wash, 3.5 miles downstream of the Irving hydroelectrical facility, until its confluence with the Verde River. The boundary of the Mazatzal Wilderness follows the "thread of Fossil Creek" from near Irving to Sally May Wash. Fossil Creek has been found to be potentially eligible for designation as a Wild and Scenic River because of its outstanding remarkable values[2]. Fossil Creek enters the boundary of the Verde Wild and Scenic River one-quarter mile east of the Verde River (Nelson 2003).

Fossil Creek is an intermittent stream from its headwaters until it reaches Fossil Springs, which are located approximately one third of the way down from the origin of the creek (Mathews et al. 1995). The numerous springs are collectively called Fossil Springs. Fossil Springs emanate from Mississippian Naco Limestone in an area spread out over approximately 900 feet in length along the creek (Monroe 2000). Spring flows emerge over about a 1,000-foot reach of Fossil Creek and flow is relatively constant at nearly 46 cubic feet per second (cfs), based on Coconino and Tonto National Forest stream flow measurements that have been ongoing since 2000. The springs discharge at a near constant temperature of 72°F making Fossil Creek one of Arizona's rare warm water streams. Fossil Springs represents the largest concentration of spring-water discharge in the Mogollon Rim region (Malusa 1997), and generates about 74 percent of the average annual total volume of water yielded by the Fossil Creek watershed at the Fossil Springs Diversion Dam location (Loomis 1994).

Figure 1. Location of Fossil Creek in north-central Arizona on the Mogollon Rim.



There are several special areas within the Fossil Creek watershed. These include the Fossil Springs Botanical Area (20-acre site containing Fossil Springs and an associated riparian deciduous forest) and the Fossil Springs Wilderness Area (11,550 acres in size). The Fossil Springs Wilderness Area and the Fossil Springs Botanical Area are on the Coconino National Forest. Another special area, the Fossil Springs Natural Area is on the Tonto National Forest. Both the Botanical and Natural Areas are above the Fossil Springs Diversion Dam, ending at, or a short distance above, the Diversion Dam.

Fossil Creek flows through one parcel (70 acres) of private property approximately one mile below Irving. Recreation areas, hiking trails and dispersed campsites along the creek are used by an ever-increasing number of people. The major land uses along Fossil Creek are recreation, livestock grazing, and until mid-2005, hydroelectric power production.

Fossil Creek supports an abundant and diverse native fish community. Native fish are found throughout the creek although, prior to the native fish restoration project (fall 2004) native fish were found in lower numbers in the reaches furthest downstream due to diversion of stream flows and competition with nonnative species. Native fish species present above the Fossil Springs Diversion Dam included headwater chub, desert sucker, and speckled dace. Below the dam these species as well as roundtail chub, longfin dace, and Sonora sucker were also present. During the late fall, 2004 a fish renovation project commenced. The Bureau of Reclamation in cooperation with the US Fish and Wildlife Service, the Arizona Game and Fish Department, and the Forest Service constructed a fish barrier approximately 5 miles upstream from the confluence with the Verde River. The stream between the fish barrier and the Fossil Springs Diversion Dam was treated with a piscicide to eradicate populations of nonnative fish. Native fish salvaged prior to the application of the piscicide were then repatriated to the stream in an attempt to restore a natives-only fishery to Fossil Creek.

Travertine

The large and sustained baseflow of Fossil Creek (recently returned fully to the Fossil Creek channel), the native fish community, and a diverse riparian community all contribute to the remarkable resource values of Fossil Creek. The factor which makes Fossil Creek truly unique is that the water discharged from Fossil Springs leads to the formation of travertine, which is calcium carbonate. The spring water that is discharged from the limestone formations at Fossil Springs contains high concentrations of calcium carbonate and dissolved carbon dioxide. As this water travels downstream and is exposed to atmospheric conditions and turbulence, carbon dioxide gas is released. This release causes the water to become supersaturated with calcium carbonate; when a critical level of supersaturation is reached, travertine precipitates from solution and deposits on the bed and banks of the channel. Most travertine deposition occurs at and below areas of turbulence, although algae also play a role in travertine deposition through the photosynthesis process, which consumes carbon dioxide (Mathews et al. 1995).

In free-flowing streams, travertine precipitates on rocks, leaves, and other objects in the channel. Encrustation of these features by travertine, forming “fossils”, accounts for the origin of the creek’s name. Typically, travertine deposition forms dams that can build up to many feet in height. Deep pools form behind these dams and a series of steps and pools are created. It is not uncommon for travertine formations to accrete several inches per year in areas of stream turbulence (Mathews et al. 1995). Deposition rates of almost one foot per month were recorded on Fossil Creek during March 1996 when the Irving Power plant was shut down for maintenance (Overby and Neary 1996).

Historic accounts predating the construction of the Childs/Irving project report large travertine structures in Fossil Creek. Early visitors to the area, Charles F. Lummis (1891) and F.W. Chamberlain (1904) describe Fossil Creek as so impregnated with minerals that it is “constantly building great round basins” that “flow down bowl after bowl”. They described dams “from several inches to few feet in height, the highest is said to be 10 feet”. According to Chamberlain's account (he did not see this reach of Fossil Creek and his account is based up local sources), travertine formations were present along “a couple of miles” of Fossil Creek beginning about a half mile below Fossil Springs (Mathews et al. 1995; pers. comm. Jerry Stefferud). Travertine formations extend along Fossil Creek nearly to Sally May Wash (pers. comm. Jerry Stefferud).

Beginning in 1916, the diversion of most of the baseflow of Fossil Creek to the Irving and Childs power plants halted travertine deposition in areas where it had occurred historically. Without the input of calcium carbonate-rich baseflows, the travertine features built up in the channel began to deteriorate (Overby and Neary 1996). The erosive power of storm water flows contributed to the degradation. With the absence of new travertine deposition, all that remains in the reach above Irving are low travertine features maintained by the 0.2 cfs flow that seeps through the diversion dam. Remnants of the travertine structures that predated the Childs-Irving project persist. Reconnaissance of the 3.4 mile reach of Fossil Creek between the diversion dam and Irving by Overby and Neary (1996) found 81 distinct sets of remnant travertine structures, located mainly at or near channel nick points where turbulence increases. Prior to the construction of the Childs-Irving facilities, it is likely that storm flows would degrade travertine structures but that they would rebuild during periods when travertine-laden baseflow comprised most of the flow in the creek.

The travertine formations at Fossil Creek result in a unique geomorphology and riparian system. Deposits of travertine are rare in Arizona. Areas with travertine such as Tonto Natural Bridge and Montezuma's Well are valued natural wonders in the southwest and are recognized as a National Monument and a State Park. Other travertine systems such as Havasu Creek and Blue Spring on the Little Colorado River, both tributaries to the Colorado River, are held sacred by Native American tribes.

Hydroelectric Generation: Childs-Irving Power Plants

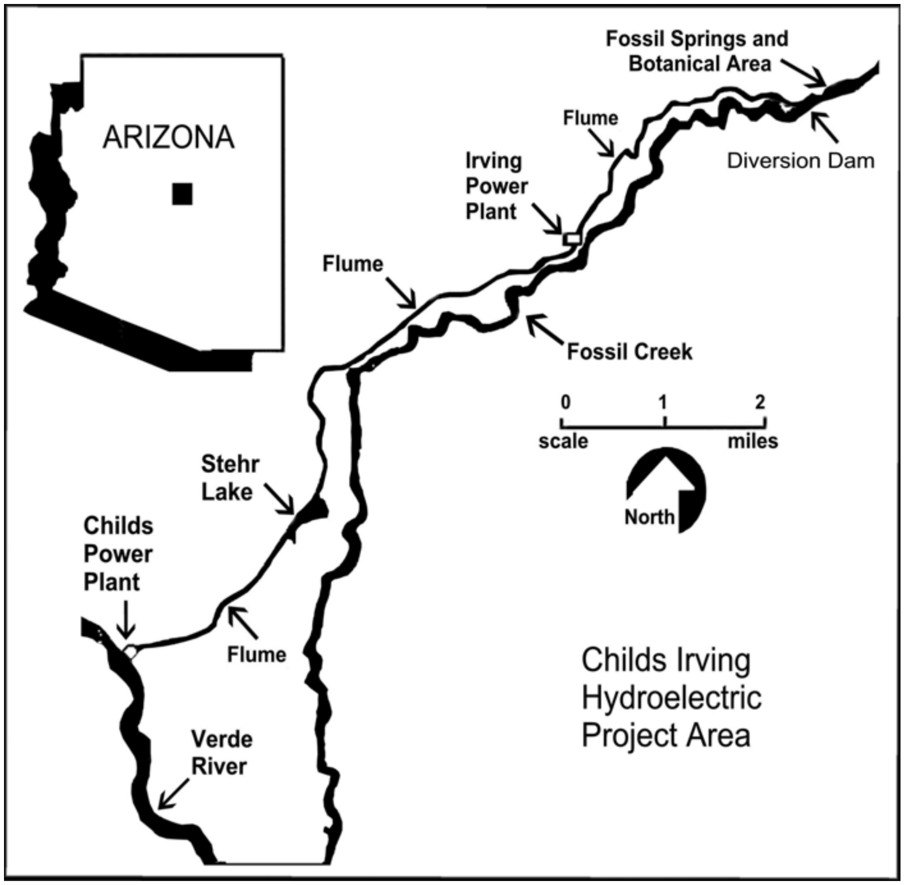
As discussed above, the Childs-Irving power plant facilities (Figure 2) have been in operation since the early 1900's and have since diverted, on a near-continuous basis, almost the entire spring-supplied baseflow of Fossil Creek for power generation.

In 1900, rancher Lew Turner filed the first claim to the water rights of Fossil Creek and planned to divert the water to generate electricity to sell to the numerous mines in the Bradshaw Mountains and the Black Hills (APS undated). Construction started in March of 1908. In 1909, most of the flow of Fossil Creek was diverted at the current Irving power plant site from the creek into a system of flumes, siphons, penstocks, a reservoir (Stehr Lake), and turbines associated with the newly-built Childs hydroelectric power plant. Childs was one of the first hydroelectric power plants built in the West. The plant sits on the banks of the Verde River. Electricity generated from the Childs plant was used by the mining industry in the Jerome area as well as by large irrigation companies and individual farmers in the Verde Valley to run pumps to water thousands of acres of land.

Because of increasing demands for power by the end of 1914 due to the revival of the mining industry and the high price of copper, the Irving Power plant was built in 1916.

In their heyday these stations supplied all the electrical needs of Yavapai County and combined they generated nearly 7 megawatts of electric power. At the present time, the combined power output of the two plants is nearly 4 megawatts.

Figure 2: Childs-Irving facilities.



Childs-Irving project facilities begin at the Fossil Springs Diversion Dam, a 25-ft high concrete structure, located approximately 0.2 mile below the lowermost spring of the Fossil Springs vent complex. This dam diverts almost the entire discharge of the springs (nearly 46 cfs) into a system consisting of a flume, a siphon and a penstock (static water pressure head of nearly 480 ft) that deliver water to the Irving Powerhouse. Approximately 0.2 cfs leak through and around the Fossil Springs Diversion Dam and maintain perennial flow in a 3.4-mile reach of Fossil Creek from the Fossil Springs Diversion Dam to the Irving Powerhouse (the Irving Reach).

To ensure an adequate, continuous supply of water to the Childs plant, Stehr Lake was built by constructing two earth-filled dams at either end of an old dry lakebed located on a natural bench above Fossil Creek; covering 27.5 acres, the reservoir allowed the Childs plant to be run when repairs and maintenance activities shut off the flume's water flow (APS undated). Originally, Stehr Lake had a water surface area of nearly 23 acres, though at the present time, open water covers only 3-4 acres, due to sedimentation and vegetative infilling along the perimeter. As part of the decommissioning activities, Stehr Lake is slated for removal and the site will be restored in 2005/2006.

An additional 2.1 miles of pressure tunnels and penstock convey Fossil Creek water from Stehr Lake to the Childs Power Plant, which is located on the banks of the Verde River, 3.5 miles upstream of the confluence with Fossil Creek.

A small cluster of employee housing and support buildings is currently permitted on National Forest System lands next to Fossil Creek to support operation of the Irving power plant, operated by APS. These structures will be dismantled and the site restored to natural conditions after the power plant ceases operation. At Childs, the powerhouse and ice house will be the only buildings that will remain on site after decommissioning activities cease. Housing is also present on Forest Service land at Childs (pers. comm. Cecilia Overby).

Presently, the power plants at Childs and Irving have a combined output of nearly 4.0 megawatts and produce 37,000 megawatt hours per year, or enough power to sustain 4,000 homes (Mathews et al. 1995). Total generating capacity of these plants is less than 0.1 percent of the total power production capacity of APS (Mathews et al. 1995).

The electricity from Childs-Irving was eventually sent to Prescott, Wickenburg, Ash Fork and Seligman. While originally used for mining purposes and agriculture, the electricity generated at Childs-Irving was eventually redirected to the growing population of Phoenix. The Childs-Irving project was designated as a National Historic Mechanical Engineering Landmark in 1976 and was entered into the National Register of Historic Places in 1991.

Travertine deposition in the concrete flume that conveys water from the Irving Powerhouse to Stehr Lake has reduced the conveyance capacity of the flume and results in discharge of an additional 2-5 cfs into Fossil Creek below the Irving Powerhouse (FERC 1997, referenced in Monroe 2002). This discharge remains in the creek in the 10 mile reach from Irving to the Verde River (the Childs Reach).

Decommissioning of Childs-Irving

Childs-Irving was issued a license for a period of 50 years on January 1, 1945 by the Federal Power Commission. In 1992, APS filed an application for a new license for the existing Childs-Irving Project. The entire relicensing process takes about 5 years and is triggered by the Federal Power Act that requires water power operators to be periodically reevaluated so that, if warranted, the operation may be either discontinued or modified, to reflect changing societal values, operational advances, or other factors (Mathews et al. 1995). In 1997, the Federal Energy Regulatory Commission (FERC) issued a Draft Environmental Assessment (DEA) on the proposal to relicense the project. The relicensing DEA considered the alternative of retiring the project, but recommended that a new license be issued but with increased flows into Fossil Creek.

After issuance of the relicensing DEA, APS entered into discussions with the intervenors in the relicensing proceeding (which included American Rivers, the Center for Biological Diversity, the Yavapai-Apache Nation, the Arizona Chapter of The Nature Conservancy, and Northern Arizona Audubon Society), and other interested entities including the U.S. Forest Service and the U.S. Fish and Wildlife Service. On September 15, 2000, APS and the other parties filed an Offer of Settlement (Settlement of Agreement) that was signed by the intervenors. The filing requested that FERC approve the surrender of the license to operate the hydroelectric project and included a proposed plan to remove facilities and restore the area. The Settlement Agreement stated that APS will cease power generation and restore full flows to Fossil Creek no later than December 31, 2004[3] and complete site restoration to the satisfaction of FERC and the Forest Service by December 31, 2009. The decommissioning of the Childs-Irving Project had to be approved by FERC and a surrender of license had to be provided to APS.

APS filed an application to surrender the license and a Removal and Restoration Plan with FERC on April 30, 2002. This plan outlined the following actions (summary from USDI 2004):

> Removal of existing above-ground structures and equipment at the Fossil Springs diversion area; (2) removal of the Irving Development's steel flume and supporting wooden trestle, and elimination and restoration of the flume road between the Fossil Springs Diversion Dam and the Irving powerhouse; (3) sealing of the Irving flume tunnel No. 1; (4) removal of the above-grade Hot Water Canyon siphon pipe, including the concrete inlet structure; (6) removal of the Irving powerhouse and related equipment, fencing, power poles, wires, and transformers; (7) removal of all buildings at the Irving powerhouse site, including seven houses, a commissary building, maintenance shop, and sheds; (8) disconnection and burial of the Irving plant potable water system (per the direction of the Forest Service); (9) removal of the concrete forebay wing walls and 5-foot-high Fossil Creek diversion dam at the Irving power plant; and (10) removal of the above-grade portions of the gravity conveyance system (consisting of concrete box flume sections, steel pipe sections, tunnel sections and steel flume sections supported on wooded trestles) between the Irving plant site and Stehr Lake.
>
> Stehr Lake, a 23-acre off-stream impoundment that serves as a forebay for the pressure tunnel and steel pipe delivery system to the Childs plant, would be dewatered, the earthen embankments breached, and the lake area returned to natural vegetation. The Stehr Lake works would be removed and the pressure tunnel sealed off at both ends. A 1,394-foot-long reinforced concrete pressure pipe from the tunnel to the concrete surge tank would be sealed at both ends and left in place; the surge tank would be removed; and the 4,635-foot-long steel penstock with diameters ranging from 48 inches to 32 inches would be sealed at

both ends and left in place. The Childs powerhouse would be left in place as an historic feature, and removal of all electrical, mechanical, and maintenance equipment. The Childs substation, located next to the powerhouse, would remain in service, with all poles, equipment, and wires not required for customer service removed.

APS will remove at a minimum the top 14 feet of the Fossil Springs Diversion Dam and may remove the entire dam depending upon the results of habitat development and sensitive species monitoring[4]. The dam will be removed in 3-foot stages, beginning in September 2007, with work expected to last 12 to 16 weeks. The final decision on how much of the dam will be removed will be made by APS and the Forest Service based upon the results of monitoring, which will occur from 2005 through 2007 (see footnote below for further details). To remove the dam, APS plans to construct a diversion channel to convey the 43 cfs base flow around the work area during dam deconstruction and until natural high-flow events transport the reservoir sediments downstream. The sediment immediately behind the dam will be excavated to a stable working slope to allow for the removal of the concrete dam. Sediment mechanically removed from the stream bed will be dewatered and used as fill in the restoration of the Irving site. Concrete removed from the dam will be disposed of in the Irving flume tunnel before sealing the tunnel entrance with concrete or placed in designated staging areas for later disposal.

At about the same time that APS was in the midst of its relicensing application preparation, the Bureau of Reclamation (Reclamation) in 1991 recognized that the Central Arizona Project (CAP) which delivers Colorado River water for agricultural, industrial, and municipal used in central and southern Arizona, could potentially affect protected native fishes. Thus, Reclamation requested formal consultation with the U.S. Fish and Wildlife Service (FWS) pursuant to Section 7(a)(1) of the Endangered Species Act. On April 15, 1994, the FWS issued a final biological opinion on the delivery of CAP water to the Gila River basin. In 1997, the Southwest Center for Biological Diversity filed suit alleging that the biological opinion's reasonable and prudent alternative did not sufficiently remove jeopardy to threatened and endangered fishes or adverse modification to their critical habitats. In September 2000, the U.S. District Court upheld the FWS' jeopardy conclusion but also held that subsequent amendments to the reasonable and prudent alternative were arbitrary and capricious. As a result, Reclamation and the FWS reentered formal consultation and the FWS issued a revised biological opinion on CAP water delivery in 2001.

The 2001 CAP biological opinion incorporated the 1994 reasonable and prudent alternatives and mitigative commitments proposed by Reclamation during reconsultation. These conservation measures required construction and operation of a single drop-type fish barrier in Fossil Creek and other specific drainage systems of the Gila River basin in Arizona and New Mexico. The Fossil Creek fish barrier would prevent non-native fish from migrating up from the Verde River.

Given the biological opinion's requirement, the Bureau of Reclamation and the Forest Service completed an environmental assessment on the restoration of Fossil Creek. This action included the construction of the fish barrier in Fossil Creek, as required under the FWS biological opinion, as well as fish salvage, stream renovation, and repatriation of native fishes. The original timeline for completion of the native fish restoration project was delayed because environmental compliance took much longer than originally anticipated. In addition, a failure of the diversion flume at the Childs-Irving Project in the fall of 2004, caused by intense rainfall from the remnants of Hurricane Javier, caused further delay in initiation of the project (letter from Reclamation to FERC, October 27, 2004). The result of these delays compressed into two months what was originally envisioned as a one-year project. It was determined that this constricted schedule which resulted from these delays would not adequately accommodate additional delays or provide a sufficient post-project monitoring period to assess the project's success. Reclamation requested all deconstruction/return of flow activities be postponed from the date determined in the Settlement Agreement (December 31, 2004) until March 15, 2005 unless otherwise notified (letter from Reclamation to FERC, October 27, 2004).

On October 8, 2004, the FERC Commission issued an order approving the surrender by APS of its license for the Childs-Irving Hydroelectric Project. The order also approved removal of project works but required APS to take certain steps prior to commencing any removal operations. Specifically, the order required APS to submit certain information to various agencies. APS provided the required documents and agency review comments to FERC on January 13, 2005. In addition, APS provided a more detailed estimate of when full flows could be expected to be allowed to return to Fossil Creek stating:

> "Based upon the schedule submitted to FERC by APS on November 8, 2004, the Commission's 60-day review would result in a response from the Commission on or near March 18, 2005. Based upon this approval date, APS could then commence ground disturbing activities, which would include the construction of the temporary bridge across Fossil Creek at Irving, on March 21, 2005. APS requires this bridge to be in place prior to return of full flows and the start of deconstruction to avoid construction traffic through the creek itself. The construction of the bridge requires eight weeks of work, which would result in a date for return of flows no later than May 13, 2005. APS will start work shortly after we receive FERC's approval and will work to return flows earlier than May 13 if possible" (letter from APS to FERC, January 13, 2005).

APS returned full flows to Fossil Creek on June 18, 2005.

Watershed Description

Charlie Schlinger and Lori Yazzie

The Fossil Creek watershed boundary (Figure 3) referred to in this report represents, in essence, a sixth order watershed (e.g. see federal standards for delineation of hydrologic unit boundaries; Version 2.0, October 1, 2004, available at: www.ncgc.nrcs.usda.gov/products/watershed/). This watershed boundary represents the contributing area for all the tributary flows into Fossil Creek. The watershed at the confluence with Verde River covers 135 square miles (86,400 acres). The watershed ranges in elevation from over 7,200 feet on the Mogollon Rim to 2,543 feet at its confluence with Verde River.

Physical and Biological Environment

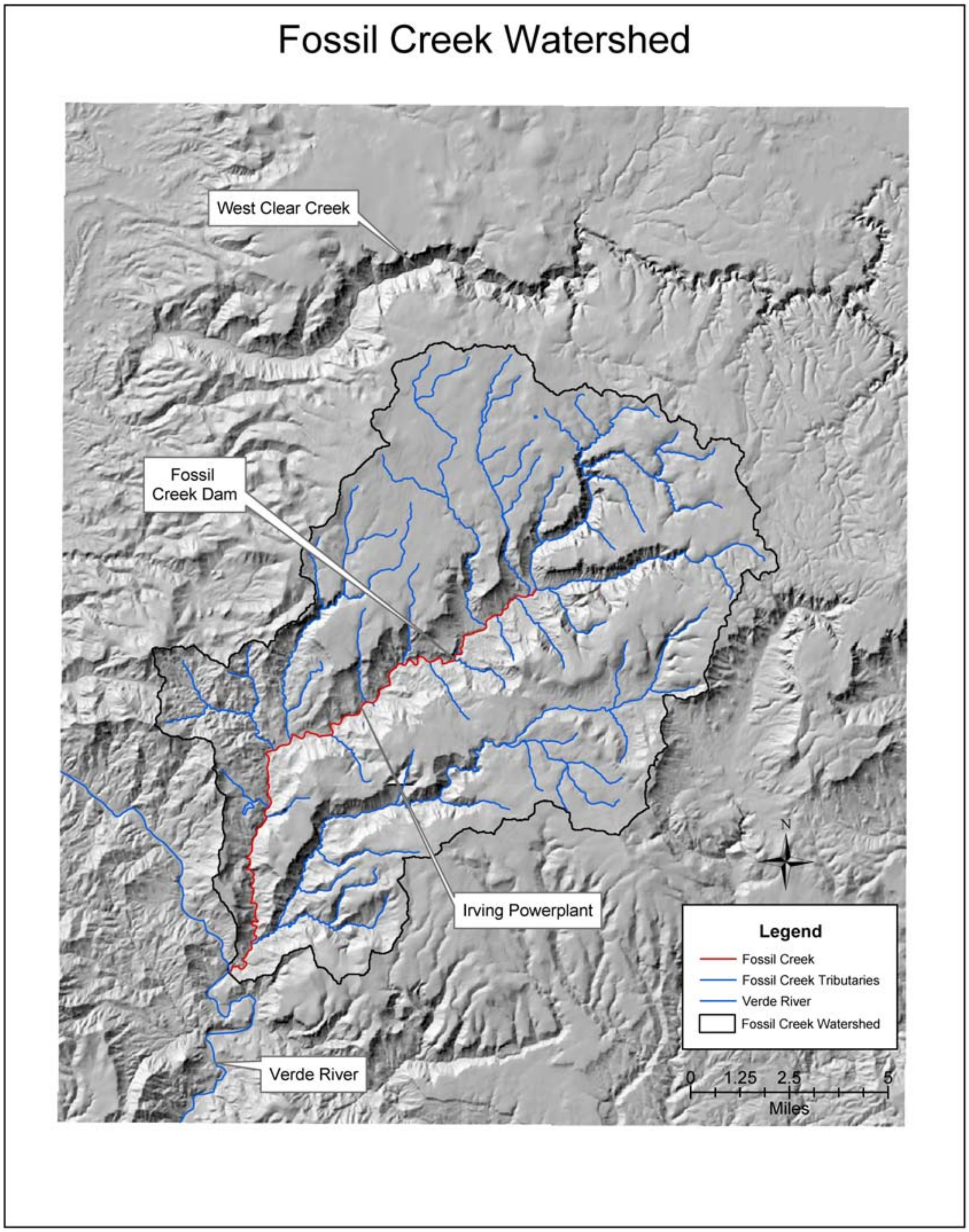
Climate

Abe Springer

Climate along Arizona's Mogollon Rim is highly variable. Precipitation is bimodal, with one distinct peak occurring in the winter/early spring and a second in late summer. Winter/early spring storms occur between December and March and are the result of cyclonic events. These cyclonic events often originate offshore in the Pacific Ocean and are typically large in aerial extent, relatively long in duration and of mild intensity. Large amounts of snowfall may occur within Fossil Creek's watershed during this time.

Summer monsoons are the result of local convective events usually originating from moisture advancing from the Gulf of Mexico. Precipitation usually occurs as thunderstorms which are often small in aerial extent and can be quite intense. Another factor is the physical geography of the Mogollon Rim. This escarpment can give rise to large storms due to the orographic effect. Warm, humid air moving northward and up gradient reaches the rim and rises rapidly. As the air mass moves upward, water condenses. The resulting clouds, segregated from the plateau by cooler air atop it, yield heavy precipitation near the edge of the rim (Sellers and Hill 1974).

Figure 3. Fossil Creek watershed (figure created by Lorrie Yazzie).



The Fossil Creek watershed (Figure 3) is located in a semi-arid climatic region, although temperature, vegetation, and precipitation vary greatly depending on elevation (Flora 2004). Average daily temperatures range from a high of 27.2º C to a low of 8.3° F at Childs. At Irving, the temperature can be as low as 0º F and at Childs the temperature can exceed 43.3° F in summer. Above the rim, in the higher elevations of the watershed average temperatures tend to be about 15° cooler (Sellers and Hill 1974). Average January temperatures range from -9.1°C to 4.9°C at Happy Jack (elevation = 2,279 meters) and -0.2°C to 15.7°C at Childs (elevation = 807 meters). Average July temperatures range from 9.1°C to 26.2°C at Happy Jack and 19.8°C to 38.8°C at Childs (Table 1, Western Regional Climate Center 2004).

Average annual precipitation on the Fossil Creek watershed ranges from 25 inches on the Mogollon Rim to 18 inches at Childs on the Verde River. At Childs, the annual precipitation for 2002 was the second lowest amount of annual precipitation from 1930 to 2002 (Figure 4). In 2002, lower amounts of precipitation occurred throughout the watershed resulting in lower than normal amounts of recharge. Although it was not measured, is it possible that the lower amounts of recharge could eventually impact the flow of Fossil Springs.

Figure 4. Annual precipitation totals measured at Childs from 1931 to 2002, Elevation = 807 meters (Flora 2004; U.S. Department of Commerce NOAA 2004).

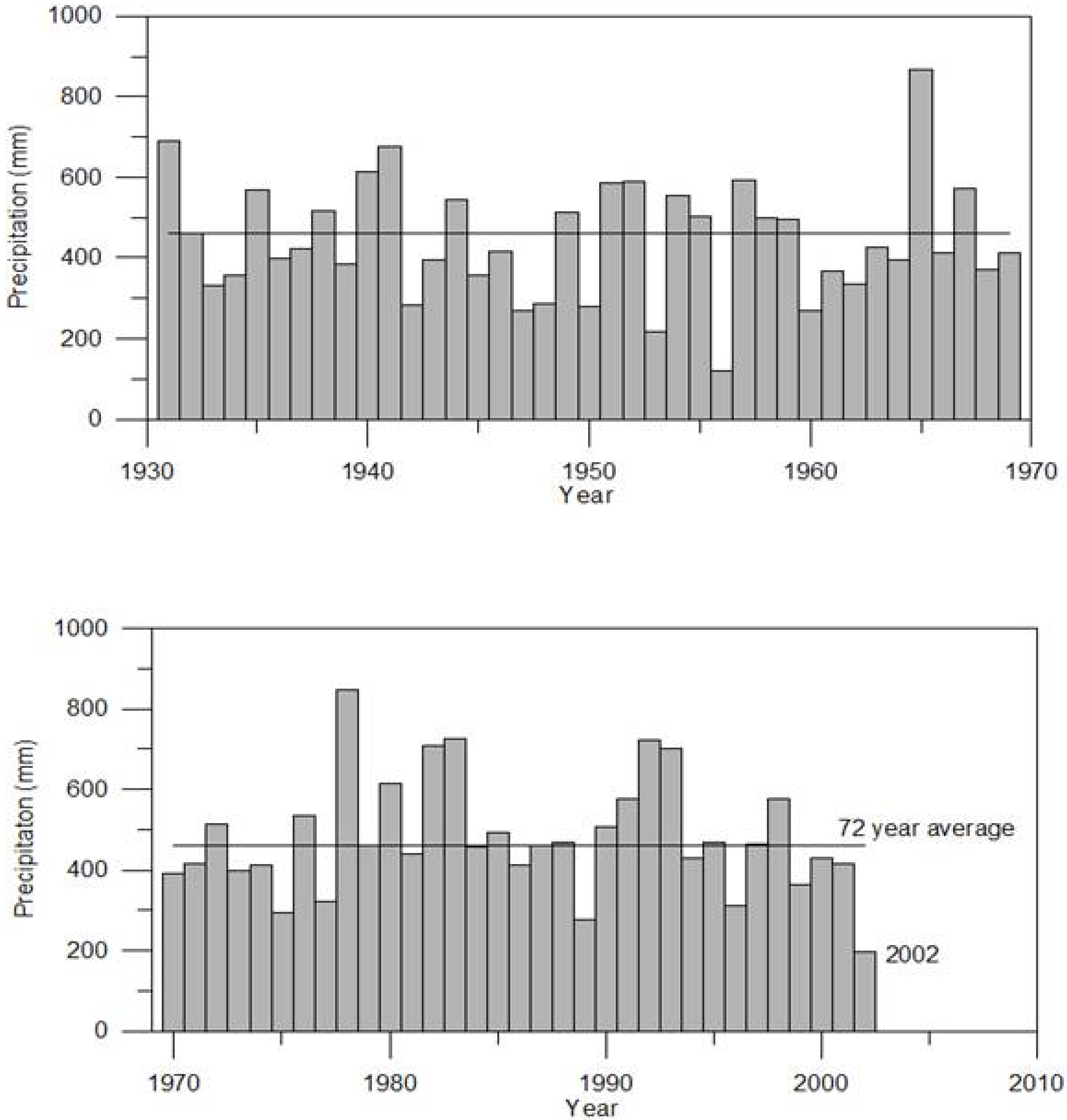


Table 1. Climate data for (A) Happy Jack, AZ and (B) Childs, AZ weather stations (Flora 2004).

A - HAPPY JACK RANGER STN, ARIZONA (023828)
Period of Record : 5/ 1/1969 to 7/31/2003

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max Temp (C)	4.9	7.4	8.8	12.6	17.8	24.2	26.2	24.7	21.7	15.5	9.3	4.5	14.8
Average Min Temp (C)	-9.1	-7.1	-6.0	-3.1	0.6	4.8	9.1	8.8	5.2	-0.7	-5.4	-9.3	-1.0
Average Mean Temp (C)	-1.8	0.3	1.4	5.0	9.1	14.4	17.7	16.8	13.4	7.4	1.9	-9.3	6.9
Average Total Precipitation (mm)	79.0	73.2	88.6	38.4	21.8	10.2	64.0	75.7	61.0	50.0	51.3	63.5	676.9
Average Total Snowfall (mm)	599.4	502.9	475.0	251.5	15.2	0.0	0.0	0.0	0.0	22.9	215.9	332.7	2413.0
Average Snow Depth (mm)	152.4	152.4	101.6	25.4	0.0	0.0	0.0	0.0	0.0	0.0	25.4	76.2	50.8

B - CHILDS, ARIZONA (021614)
Period of Record : 9/ 1/1915 to 7/31/2003

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max Temp (C)	15.7	18.4	21.3	26.1	31.4	36.9	38.8	37.2	34.7	29.0	21.5	16.1	27.3
Average Min Temp (C)	-0.2	1.5	3.4	6.7	10.6	15.1	19.8	18.9	15.3	9.1	3.2	0.3	8.7
Average Mean Temp (C)	7.7	10.0	12.4	16.4	21.0	26.0	29.3	28.1	25.0	19.1	12.4	8.2	17.9
Average Total Precipitation (mm)	49.0	46.5	45.0	23.9	10.2	8.9	49.8	67.3	43.2	30.5	31.8	51.1	457.2
Average Total Snowfall (mm)	7.6	10.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	2.5	22.9
Average Snow Depth (mm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Soils[5]
Rory Steinke

Introduction

This existing condition report assesses soil condition in the Fossil Creek Planning Area located entirely within the Fossil Creek – Lower Verde River Hydrologic Unit 5th code watershed, Coconino National Forest (see Figure 5). The Fossil Creek – Lower Verde River Hydrologic Unit 5th Code watershed condition assessment is a separate watershed condition assessment and describes watershed condition of areas draining into Fossil Creek and the lower Verde River.

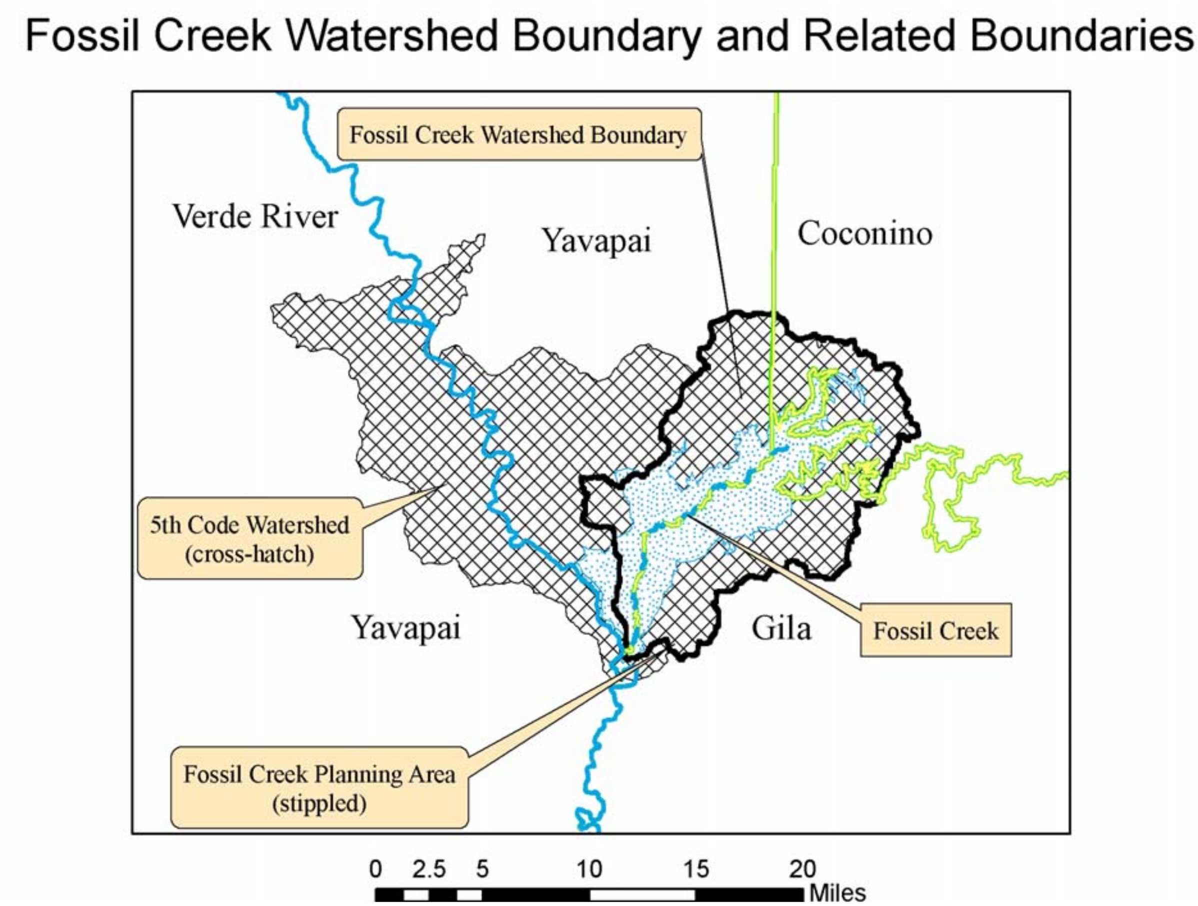
The Fossil Creek Planning Area boundary encompasses parts of the Coconino and Tonto National Forests. This planning area includes all of Fossil Creek itself and a large portion of the watershed draining into Fossil Creek. The Terrestrial Ecosystem Survey was clipped to the planning area boundary. Based on this GIS operation, there are 36,225 acres in the planning area.

Overall watershed condition is based on evaluation of the soil, aquatic and riparian (including vegetation) systems as prescribed by the watershed classes defined in Forest Service Manual 2520. A description of how watershed condition and classes are derived is found in Forest Service Manual 2520.

Soil Condition

An important component of watershed condition is soil condition. The Terrestrial Ecosystem Survey (TES) for the Coconino National Forest (USDA 1995) and the Tonto National Forest were the basis for our soil condition assessment (USDA 1985). The soil condition ratings are based on interpretations of the three primary soil functions: soil hydrologic function, soil stability and nutrient cycling. The Coconino and Tonto National Forests TES based soil condition primarily on quantitative on-site erosion rates (stability) measured and predicted by the Universal Soil Loss Equation (USLE). Since its publication in 1995, a new approved soil condition protocol was developed in R3 (FSH 2509.18-99-1) assessing three soil functions including the ability of the soil to resist erosion, infiltrate water and recycle nutrients. Due to a lack of newer data, the assessment used in this analysis is based primarily on the ability of the soil to resist erosion however, numerous refined on-site soil condition assessments were made primarily on slopes of less than 40 percent on the Coconino National Forest. On the Tonto National Forest, no on-site soil condition assessments were made and soil condition classes are based primarily on soil stability as predicted by the USLE, and professional judgment of the Forest Soil Scientist Norm Ambos.

Figure 5. Fossil Creek Watershed boundary and related boundaries (figure created by Charlie Schlinger).



Erosion and its consequence, sedimentation, are generally considered to be the number one problem associated with watershed management (Dissmeyer 2000).

The Fossil Creek planning area encompasses acreage from both the Coconino and Tonto National Forests. Therefore, this report combines TES mapping from both forests. On the Coconino National Forest, we make one soil condition call per TES map unit except on map units 33 and 46 located in riparian areas where a dual class is used. In multi-component TES units (complexes) we used the more limiting component (in a reduced soil condition class) if the aerial percentage was 30 percent or more. The Tonto National Forest used dual classes where soil map unit design indicated more than one soil condition class exists.

A map unit is a collection of areas defined and named in terms of their soil/vegetation/climate components. Each map unit differs in some respects from all others in a survey but is comprised of each major component identified in the map unit legend. Soil condition may vary within the same map unit across the landscape due to differences in disturbance. On-site investigation is recommended to validate soil condition or rate soil condition including all three-soil functions on a large-scale (small acreage basis).

Definitions:

Unsatisfactory: Soil indicators signify that a loss of soil function has occurred. Degradation of vital soil functions result in the inability of the soil to maintain resource values, sustain outputs or recover from impacts. Unsatisfactory soils are candidates for improved management practices or restoration designed to recover soil functions.

Impaired: Soil indicators signify a reduction in soil function. The ability of the soil to function properly and normally has been reduced and/or there exists an increased vulnerability to degradation. An impaired category indicates there is a need to investigate the ecosystem to determine the cause and degree of decline in soil functions. Changes in land management practices or other preventative measures may be appropriate.

Satisfactory: Soil indicators signify that soil function is being sustained and soil is functioning properly and normally. The ability of the soil to maintain resource values and sustain outputs is high

Table 2. Soil condition in the Fossil Creek Planning Area.		
Soil Condition Class	**Acres**	**Relative Percent**
Satisfactory	5772	16
Satisfactory – Inherently Unstable	17,939	49
Satisfactory and Impaired	196	1
Satisfactory and Unsatisfactory	766	2
Impaired	5054	14
Impaired and Unsatisfactory	3799	10
Unsatisfactory	2699	8
TOTAL % (Acres):		
	36,225	100

Unsatisfactory Soil Condition

Most of these soils are in accessible areas subject to grazing. These soils have current erosion exceeding tolerable limits and overall amount to 8 percent of the planning area (Table 2). Most of these soils are located in juniper-grassland transition zones. Soil indicators signify that a loss of soil function has occurred. Most identified unsatisfactory soils result from high levels of historic grazing pressure and continued grazing probably beyond the carrying capacity of the land. Past grazing practices have contributed to accelerated erosion with detachment and transport of sediment resulting in a reduction of long-term soil productivity. A decrease in long-term soil productivity does not necessarily equate to sediment delivery into nearby drainage systems or downstream into areas of loach minnow and spinedace designated critical habitat. However, some sediment may be transported into ephemeral and intermittent streams, eventually connecting to perennial streams. Much of the sediment is redeposited on the uplands before reaching any drainage system and cannot be equated to sedimentation. The USLE is not intended to be a tool to determine sediment yield and delivery into streams. Sedimentation is a natural product of forestland, where in proper amounts, is essential to the well being of stream ecosystems. It provides a rooting medium for aquatic plants, spawning gravel for fish, shelter for small aquatic plants, and conveys nutrients into streams necessary by all biota (Patric 1982).

The Tonto National Forest, most riparian areas have unsatisfactory soils in areas of designated critical habitat for loach minnow and spikedace adjacent to the Verde River. Although no on-site data has been collected, the Forest Service believes it is likely that there are no unsatisfactory soils adjacent to Fossil Creek below Stehr Lake due to the inaccessible nature of this reach.

There are small areas of unsatisfactory soils (TES units 33 and 46) adjacent to Fossil Creek, the Verde River and other perennial streams in the planning area. Where access is favorable to dispersed camping, recreation and grazing, these riparian areas tend to exhibit reduced vegetative ground cover (litter and basal vegetation) and increased soil compaction resulting in accelerated soil erosion and decreased soil productivity.

The northwest portion of the watershed contains sizeable acreage of unsatisfactory soils. During high intensity storm events, it is possible that these upland areas may deposit sediment into both Sycamore Canyon and Cottonwood Creek neither of which are perennial streams. Another sizeable area with unsatisfactory soils occurs adjacent to Boulder Creek and middle reaches of Fossil Creek. Additional areas occur scattered throughout the watershed and planning area and may contribute a little more sediment downstream than would occur under areas with satisfactory soil condition. Following intense storms, peak flows probably are amplified and *short*-term increases in turbidity probably occurs downstream into areas of perennial streams and loach minnow and spikedace designated critical habitat.

Most sediment probably comes from connected disturbed areas (roads) located in or near stream channels and naturally erosive soils found on steep slopes throughout the watershed and planning area. These roads provide an avenue from which surface runoff may carry sediment laden water and deliver it into a stream that eventually drains into downstream perennial waters. Additional sediment probably comes from inherently erosive soils on slopes greater than 40 percent (Satisfactory-Inherently Unstable) soils in areas largely inaccessible to grazing.

Satisfactory-Inherently Unstable

TES map units 350, 430, 3339, 3712, 4176, 9239, and 9349 (located throughout the planning area and on steep slopes) are rated as satisfactory-inherently unstable. These soils are located primarily in pinyon-juniper – chaparral vegetation types. These soils have natural erosion exceeding tolerable limits and overall amount to 17, 939 acres or 49 percent in the planning area. Based on the Universal Soil Loss Equation (USLE) these soils are eroding faster than they are renewing themselves and are functioning properly and normally. Almost all acreage in this class occurs on slopes greater than 40 percent and is located in the central and western portions or the planning area. Due to the predominantly steep nature of the terrain, livestock are forced to graze on accessible areas with slopes ranging from 40 to 60 percent. Past and current grazing pressure in these areas may have caused accelerated soil erosion with a decrease in long-term soil productivity. It is not known how many acres are grazed or if grazing pressure has further impaired these soils.

Limited on-site soil condition refinement on TES map unit 430 indicates steep slopes where livestock access is prohibited generally have vegetative ground cover, and species composition similar to the potential plant community. However, based on estimates as predicted by the USLE, natural erosion rates are higher than tolerable indicating inherently unstable soil condition.

TES mapping includes up to 15 percent of other soils or lesser slopes in to the map unit design. Visual on-site investigations show slopes of less than 40 percent are common and in select areas, may include up to 25 percent of any one TES polygon. These areas typically have slopes ranging from 25 – 40 percent and are located on the footslopes of hills and mountains. These areas probably are not inherently unstable based on erosion as predicted by the USLE. Soil condition may be either unsatisfactory or impaired.

The processes of sediment delivery and effects to perennial streams and areas of designated critical habitat are similar to areas with unsatisfactory soil condition areas.

Impaired

Excessive livestock grazing may compact soil and reduce the soils ability to accept, hold, and infiltrate water. 5054 acres are rated as impaired soil condition and amount to 14% of the planning area. These soils have reduced ability to accept, hold, and release water and are generally caused by ungulate grazing and recreation use. On-site soil condition assessments were made and identified several TES units as impaired. It is not precisely known how many additional acres are impaired or unsatisfactory due to physical compaction or trampling by livestock in the planning area. It is likely that more impaired areas exist but would require additional on-site assessment to accurately display these numbers. Most identified impaired soils result from high levels of historic grazing pressure and continued grazing probably beyond the carrying capacity of the land. There are identified impaired soils adjacent to areas of perennial streams and critical habitat along Fossil Creek, and the Verde River.

Where impaired soils exist, they are found on plains and hill slopes in pinyon-juniper and juniper-semi-desert grassland transitional vegetation types or adjacent to Fossil Creek on the Coconino National Forest. Since these soils are found on both flat slopes and moderately steep slopes, surface runoff varies from slow to fast and accelerated peak flows or reduced baseflows vary accordingly. It is unlikely that these soils significantly alter water quantity, and timing of flows sufficient to adversely affect riparian habitat vegetation, and fluvial geomorphology, as long as the streambanks are protected with adequate vegetation to withstand peak flows. Beyer (1997) has concluded that the Verde River is capable of handling sediment (indicating a certain level of stream stability) during large storm events.

Satisfactory Soil Condition

The majority of satisfactory soil conditions occur in pinyon-juniper or ponderosa pine vegetative types and are commonly grazed on slopes less than about 40 percent. Approximately 17 percent of the planning area has satisfactory soil condition (Tables 3 and 4). Indicators signify that soil function is being sustained and soil is functioning properly and normally. For satisfactory soils, the ability of the soil to maintain resource values and sustain outputs is high.

Satisfactory and Unsatisfactory

TES units 33 and 46 are identified in this class and are located in riparian areas. There are small areas of unsatisfactory soils mixed with satisfactory soils (TES units 33 and 46) adjacent to Fossil Creek, the Verde River and other perennial streams in the planning area. Where access is favorable to dispersed camping, recreation and grazing, these riparian areas tend to exhibit reduced vegetative ground cover (litter and basal vegetation) and increased soil compaction resulting in accelerated soil erosion and decreased soil productivity.

Satisfactory and Impaired

TES map unit 3231 on the Tonto National Forest fits this class and is very limited in extent (196 acres). This map unit has 2 major soil components and may have both soil condition classes present. On-site investigation should be conducted to validate the soil condition.

Impaired and Unsatisfactory

TES map units 3710 and 4140 are located on the Tonto National Forest in pinyon-juniper woodlands. These map units have either two major soil components with distinct soil loss tolerances and erosions rates resulting in impaired and unsatisfactory soil conditions or vary in soil condition throughout their range.

Table 3. Soil condition class by TES map unit – Coconino National Forest.

TES Map Unit Symbol	Acreage	Vegetation Type	Soil Condition Class
33	371	Riparian	Satisfactory & Unsatisfactory
45	112	Pinyon-juniper-evergreen oak in drainageways	Satisfactory
46	370	Riparian	Satisfactory & Unsatisfactory
350	79	Semi-desert grassland	Sat. - Inherently Unstable
382	195	Semi-desert grassland	Impaired
402	527	Juniper-semidesert grassland	Unsatisfactory
403	14	Juniper-semidesert grassland	Impaired
404	440	Juniper-semidesert grassland	Unsatisfactory
420	1468	Juniper-semidesert grassland	Unsatisfactory
430	12,113	Pinyon-juniper-evergreen oak	Sat. - Inherently Unstable
457	257	Pinyon-juniper woodland	Impaired
458	343	Pinyon-juniper woodland	Impaired
462	69	Pinyon-juniper woodland	Impaired
463	1231	Pinyon-juniper woodland	Impaired
492	63	Pinyon-juniper woodland	Satisfactory

493	9	Pinyon-juniper woodland	Satisfactory
495	5	Pinyon-juniper woodland	Satisfactory
520	0	Ponderosa pine-pinyon-juniper	Satisfactory
530	87	Ponderosa pine-juniper-evergreen oak	Unsatisfactory
550	118	Ponderosa pine-Gambel oak	Satisfactory
555	4261	Mixed conifer	Satisfactory
567	11	Ponderosa pine-juniper-Gambel oak	Satisfactory
572	422	Ponderosa pine-juniper-evergreen oak	Satisfactory
578	5	Ponderosa pine-juniper-Gambel oak	Satisfactory
584	19	Ponderosa pine-Gambel oak	Satisfactory
Lake	28		Satisfactory

Table 4. Soil condition class by TES map unit – Tonto National Forest.

TES Map Unit Symbol	Acreage	Vegetation Type	Soil Condition Class
9	232	Mesquite-dry riparian	Unsatisfactory
3050	85	Juniper-semidesert grassland	Satisfactory
3187	32	Juniper-semidesert grassland	Unsatisfactory
3231	196	Juniper-semidesert shrubland	Satisfactory and Impaired
3339	293	Juniper-semidesert shrubland	Sat. - Inherently Unstable
3521	1698	Juniper-semidesert shrubland	Impaired
3710	3123	Pinyon-juniper woodland	Impaired and Unsatisfactory
3711	1188	Pinyon-juniper	Impaired

		woodland	
3712	369	Pinyon-juniper – evergreen oak woodland	Sat. - Inherently Unstable
3770	126	Pinyon-juniper – evergreen oak woodland	Impaired
4140	676	Grassland	Impaired and Unsatisfactory
4176	16	Pinyon-juniper – evergreen oak woodland	Sat. - Inherently Unstable
5550	264	Ponderosa pine-juniper-evergreen oak	Satisfactory
5551	325	Ponderosa pine-juniper-evergreen oak	Satisfactory
6405	45	Mixed conifer	Satisfactory
9239	684	Desert and semidesert shrubland	Sat. - Inherently Unstable
9349	4395	Juniper woodland	Sat. - Inherently Unstable

Summary

Upland soil conditions are variable, with the majority of the areas rating satisfactory – inherently unstable on slopes greater than about 40 percent. Following intense storms, areas adjacent to streams and drainageways leading into perennial streams likely contribute significantly to short-term increases in downstream turbidity. Where recreation access is favorable, soil condition is generally impaired or unsatisfactory but limited in overall extent. Impacts to Fossil Creek, the Verde River, and other perennials are localized and generally limited to 1/10th of an acre/dispersed site. Although seemingly small, the incremental impact of continued use (especially along the middle reach of Fossil Creek) probably results in decreased streambank vegetation, increased sedimentation and peakflows as compared to natural conditions with satisfactory soils and well-vegetated streambanks. High levels of historic grazing coupled with current grazing strategies have contributed to soil degradation. In identified areas of impaired, unsatisfactory and satisfactory – inherently unstable soils, long-term soil productivity is reduced. The physical and biological conditions of the soil system are at risk, or do not support additional disturbance including grazing activity beyond the current carrying capacity.

Water

Watershed Hydrology, Watershed and Channel Conditions, and Water Rights

Charlie Schlinger and Grant Loomis

Introduction and Overview

This section addresses watershed hydrology and channel condition with supplemental material on water rights. These elements are priorities for land and resource managers and decision makers, and may be of interest to recreational and other visitors to the watershed in general and to the riparian/channel environment in particular.

In preparing this section, we have drawn heavily, paraphrasing in places, on a report by Nelson (2003), as well as volumes II and III of the 1992 license application prepared for the Child Irving hydroelectric project (APS 1992).

Fossil Creek is a tributary to the Verde River and falls within the Verde River watershed. Regional overviews that consider the upper and middle Verde River watershed are available from ADWR (2000) and Barnett & Hawkins (2002). Though these overviews provide minimal information on Fossil Creek itself, they provide a regional perspective in which one can more clearly understand Fossil Creek hydrology and watershed condition.

Hydrology

Fossil Creek is an intermittent stream from its headwaters at the confluence of Sand Rock and Calf Pen Canyons to Fossil Springs, flowing in response to summer thunderstorms, widespread frontal storms and snowmelt runoff. Perennial flow in Fossil Creek begins where a complex of springs emerge over a 1,000 foot reach of the creek that ends approximately 1000 feet upstream of the Fossil Springs Diversion Dam. Fossil Springs reportedly discharge at a constant temperature of 72ºF (Overby and Neary 1996). Nineteen concurrent flow measurements by Tonto National Forest hydrologists above and below the springs from 2000 to 2004 result in a median flow of 46.1 cfs, and an average flow of 46.3 cfs, from the springs.

Continuous site-specific stream gage data are not available for Fossil Creek. The US Geological Survey has operated a gage on the flume from Irving to Stehr Lake since 1952. This gage is known as *Fossil Creek Diversions to Childs Power Plant, Near Camp Verde. AZ, gage No. 09507500*. It measures the flow diverted at Irving and is located just upstream of Stehr Lake. It does not record flows discharged from Irving to the Fossil Creek channel (estimated at 2-5 cfs) or flood flows down the mainstem of Fossil Creek. The gage does indicate the long term and constant nature of the baseflows discharged from the springs that is available for power generation at both Irving and Childs, and to the channel, once decommissioning of these plants commences. Average monthly flow at this gage ranges from 39.5 cfs in April to 43 cfs in July through

September. Months of no flow are included in this average during periods when the power plants or flumes were shut down for maintenance. Median monthly flows range from 43 to 44 cfs.

The watershed area that is tributary to stream flow at the Fossil Springs Diversion Dam location is 55 sq mi (APS 1992; Loomis 1994). Average annual water yield of the Fossil Creek watershed above the Fossil Springs, (with a tributary area of nearly 55 sq mi) is estimated at about 11,900 ac-ft per year based on comparisons with similar nearby gaged watersheds (West Clear Creek, Wet Bottom Creek, Red Tank Draw & Dry Beaver Creek) and from published runoff values for the vegetation communities occupying the watershed. Thus, the average annual basin water yield jumps at the springs, where the average spring discharge of 46 cfs adds 33,300 acre feet annually for a total yield of 45,200 acre feet per year. Thus, the Fossil Springs provide approximately 74 percent of the average annual basin yield above the diversion dam.

The estimated monthly distribution of the average annual water at the location of Fossil Springs is provided below. The distribution is developed using monthly runoff distributions from nearby gages on West Clear Creek, Red Tank Draw, Dry Beaver Creek, and Wet Bottom Creek. The percent contribution of discharge from Fossil Springs during each month is also tabulated (based on an average discharge of 46 cfs) in Table 5.

Table 5. Estimates of monthly precipitation at Irving, runoff (based on data for nearby gaged watersheds), contribution from springs (46 cfs or 33,000 ac-ft/yr), and total streamflow at location of Fossil Springs

Month	Average Monthly Rainfall (inches)	Average Monthly Runoff (ac-ft)	Average Monthly Runoff (cfs)	Percent of Annual Runoff	Average Monthly Total Streamflow (cfs)	Percent of Streamflow From Springs (%)
Jan	2.29	1,180	19.5	9.9	65.5	70
Feb	1.86	2,420	39.9	20.3	85.9	54
March	2.14	3,240	53.5	27.2	99.5	46
April	1.16	1,680	27.7	14.1	73.7	62
May	0.54	180	2.9	1.5	48.9	94
June	0.50	60	1.0	0.5	47	98
July	2.20	80	1.4	0.7	47.4	97
August	2.71	150	2.5	1.3	48.5	95
September	1.55	330	5.5	2.8	51.5	89
October	1.48	460	7.7	3.9	53.7	86
November	1.49	550	9.0	4.6	55	84
December	2.02	1,570	26.2	13.2	72.2	64
Total	19.94	11,900	16.4	100	62.4	74

From this table it is evident that snowmelt runoff and widespread frontal storms from December through April generate the majority (85%) of the watershed runoff at the location of Fossil Springs. Even though about one third of the precipitation occurs during the summer, the percentage of annual runoff during that period is negligible (5.3%). August is the wettest month of the year, yet less than 2 percent of the total annual runoff occurs during this month. The reduced runoff can be attributed to the high air temperatures and associated high rates of evapotranspiration that are common to this area of Central Arizona. Although contribution to stream flow from Fossil Springs averages approximately 74 percent on an annual basis, contribution to stream flow ranges from a low of 44 percent in March when watershed runoff is greatest to a high of 98 percent in June when watershed runoff is negligible. Discharge from Fossil Springs provides greater than 90 percent of the total stream flow through the summer months.

Evaluation of annual flow duration curves for neighboring watersheds suggests that stream flow in Fossil Creek consists almost entirely of baseflow (discharge from the springs) about 77 percent of the time. Watershed runoff contributes substantially to stream flow the remaining 23 percent of the time.

Peak flows at the location of the Fossil Springs Diversion Dam, and at several other downstream locations, were estimated as part of the 1992 APS re-licensing application process (APS 1992; Loomis 1994), and as part of pre-decommissioning evaluations of diversion dam removal scenarios (Schlinger et al. 2002; 2003). A compilation of peak flows estimated for the diversion dam site appears in Table 6 below.

Table 6. Estimated peak storm flows at the Fossil Springs Diversion Dam site

Recurrence Interval (yr)	**USGS Regression Equations[1] Arizona Public Service Company 1992)**	**USGS Flood Regression Equations[2] (Monroe 2002; Loomis, 1994)**	**USFS HEC-1 Current Condition (Loomis 1994)**	**HEC-HMS Spring Cyclonic Storm – Current Condition (Schlinger et al. 2002, 2003)**
2	600	508	1,026	1,077
5	1,700	1,979	2,257	2,317
10	2,900	3,348	3,737	3,235
25	4,900	5,971	6,034	4,539
50	7,000	9702	8,998	5,609
100	9,400	14200	13,531	6,743
500	16,800	–	–	–

[1] regression equations, now obsolete, of Roeske (1978)
[2] regression equations of Thomas et al. (1994)

These projections verify that estimated peak flow magnitudes are dependent on the rainfall distribution assumed for the simulation. In particular, the spring cyclonic storm considered by Schlinger et al. (2002; 2003) is less 'flashy', with peak precipitation occurring later in the storm and being longer in duration and lower in intensity. However, in the case of each estimate, the hydrologic model used was uncalibrated – due to the absence of streamflow gage data for Fossil Creek. The data in the table thus provide only 'ballpark' estimates.

Flood flow estimates for other locations in the watershed appear in Table 7 below. Boulder Creek is a tributary of Fossil Creek that enters Fossil Creek, from the north, nearly 3 miles below Irving.

Table 7. Peak flows at other locations – from USGS Regression Equations[1] (APS 1992; after Roeske 1978)

Recurrence Interval (yr)	**Fossil Creek at Irving**	**Fossil Creek 4 miles below Irving**	**Boulder Creek**
2	700	1,000	200
5	2,100	2,800	700
10	3,500	4,700	1,200
25	6,100	8,200	2,100
50	8,700	11,900	3,100
100	11,800	16,000	4,200
500	21,300	29,300	7,800

[1] regression equations, now obsolete, of Roeske (1978)

The watershed area tributary to flow: at Irving is 64 sq mi; at a location 4 miles below Irving is 90 sq mi; in Boulder Creek is 12 sq mi.

Watershed and Channel Conditions

Beginning around 1880 and continuing into the early 20th century (c. 1920), overgrazing was rampant in many Arizona watersheds; see Barnett and Hawkins (2002) for an excellent discussion. Fossil Creek was no exception (Chamberlain 1904) in this regard. As a consequence, excessive runoff, erosion in the channel and in the uplands, headcutting and loss of riparian habitat occurred. The evidence for channel erosion and downcutting is evident at many locations along Fossil Creek. The diversion of the travertine-forming Fossil Creek baseflow for Childs-Irving facility operations (Overby & Neary 1996) by the Fossil Springs Diversion Dam, and, to a lesser extent, the influences of this heavily degraded watershed condition, coupled with floods (APS 1992) led to the destruction of travertine dams since 1916.

Loomis (1994) completed a hydrological evaluation of that portion of the Fossil Creek watershed that is tributary to flow at the Fossil Springs Diversion Dam, with an eye toward assessing the effects of watershed condition on flood peaks in Fossil Creek. Loomis evaluated the then-existing watershed condition using the draft edition Coconino National Forest Terrestrial Ecosystem Survey, or TES (USDA Forest Service 1995), which covers the watershed above the diversion dam. He determined that the then-current condition of the watershed would not significantly impact flood flows, relative to the ungrazed condition, though small impacts were estimated.

It is important to note that effects of watershed condition on the forecasted flood flow magnitudes were greater for more frequent than for less frequent floods. Watershed condition is known to have a greater impact on runoff generation at lower rainfall amounts than at higher rainfall volumes associated with the more rare floods, where the sheer volume of precipitation dominates (e.g., Schlinger et al. 2004). For example, after watersheds burn, dramatic increases in runoff occur for low-recurrence-interval frequency storms, with less dramatic increases for high-magnitude low-frequency storms (e.g., Nasseri 1989; Schlinger et al. 2004). In the Fossil Creek watershed, relative to the current condition, the flows for the degraded condition were 10% larger for the 2-yr flood and 4% larger for the 100-yr flood.

Watershed sediment yield was estimated by Monroe (2002), using a variety of methods, but the results spanned 4 orders of magnitude. Given that there are no data on sediment yield due to natural erosion in the watershed, and given the wide range of these forecasts, it is impossible to interpret stream channel sediment transport simulation results (presented below) in the light of erosion and sediment transport that occur in the upland areas of the watershed.

Stream Channel and Floodplain Morphology and Sediment

An overview of Fossil Creek stream channel morphology has been provided by Nelson (2003), and we quote:

> *The stream channel morphology from the springs to the Fossil Springs Diversion Dam impoundment consists of runs, steps, riffles and deep pools. The substrate is primarily cobble and boulders. The dam has trapped an estimated 25,000 cu yd, deposited in the impoundment area upstream of the dam and resulted in an area of finer grained sediments that has developed into a wider floodplain than exists along unimpacted reaches of the channel. Mature riparian vegetation has developed on this floodplain.*
>
> *Below the dam the gradient is steep (almost 3%) and the stream flows through a narrow canyon before reaching the Irving power plant. Substrate is mostly cobble and boulder with significant exposures of bedrock. Overby and Neary (1996) mapped the remnants of 81 travertine dams in the 4 mile reach from the diversion dam to Irving.*

Below Irving, a discharge of 2-5 cfs from the power plant into the natural channel has resulted in deposition of a series of travertine dams ranging up to about 6 feet in height that extend downstream for approximately 2.5 miles to below the confluence with Boulder Creek. Travertine deposits in this reach have widened the wetted perimeter of the channel and resulted in areas of lush emergent and riparian vegetation. This reach may be representative (although at a smaller scale) of conditions that can be expected in the reach above Irving when full flows return to the channel.

Shortly below the confluence with Boulder Creek the channel becomes more confined and riparian vegetation is limited to narrow discontinuous stringers. Substrate again is dominated by cobbles boulders and bedrock. Approximately 1.5 miles below the confluence with Boulder Creek the channel enters a narrow confined canyon that is characterized by a step pool system dominated by cobbles, boulders and bedrock. Gradient increases from about 1.5% in the upstream reach to about 2.5% through the canyon. Riparian vegetation is again limited to narrow stringers due to the confining canyon walls. The canyon reach extends downstream for approximately 2.5 miles.

Below the canyon to the confluence with Hardscrabble Creek the valley bottom widens, gradient flattens to about 2%, and some discontinuous floodplain and terrace surfaces are present. Riparian vegetation is more continuous in this reach.

Below the confluence with Hardscrabble Creek to the confluence with the Verde River, a distance of approximately 1.3 miles, the gradient flattens to about 1.5%, the valley bottom remains comparatively wide and aerial photos indicate active unvegetated point or alternating bars are present. Some patchy vegetation exists on floodplain surfaces.

As stated above, the sediment that is presently stored behind the Fossil Springs Diversion Dam is relatively fine-grained. This 'sediment wedge' received considerable attention in the past few years (Monroe 2002; Schlinger et al. 2002; 2003), mainly with an eye toward how rapidly and how much of this sediment would be transported downstream following partial or complete removal of the dam.

High-resolution topographic survey data (with tree locations) for the diversion dam and extending 1200 ft upstream, just beyond the limits of the sediment wedge were obtained by APS in 2000. Schlinger et al. (2002; 2003) supplemented these data with high-resolution topographic survey data for the reach that extends downstream of the dam for a distance of nearly 350 ft. Monroe (2002) provided a survey of the sediment wedge that included the distribution of surficial sediment, the water surface and trees.

Channel and floodplain sediment grain-size distributions based on pebble-counts have been obtained both upstream and downstream of the dam by Monroe (2002) and Schlinger et al. (2002; 2003). Flood reconstruction based on geomorphic evidence and HEC-2 simulations of channel hydraulics were prepared for 4 sites in Fossil Creek (work by CH2MHill, documented by APS 1992). Floods with recurrence intervals between 30 and 300 years appear to have occurred in the past 100 years, with peak flow velocities approaching 8 to 19 ft/second – capable of transporting cobbles and small boulders. It is not possible to say whether the water surface elevations recorded by CH2MHill for the largest flood reflect current channel conditions or channel conditions early in the 20th century, when large travertine dams were extensively present in portions of the channel.

Loomis (1994) estimated the average tractive force and the average maximum diameter of sediment that will be set in motion during floods with recurrence intervals of 10-, 50- and 100- years. A summary table follows.

Table 8. Flood intervals, flood flow, average tractive force and average diameter of sediment set in motion.

recurrence interval (yr)	**flood flow (cfs)**	**average tractive force (lb/ft^2)**	**average maximum diameter of sediment set in motion (inches)**
10	3,737	5.6	10.8
50	8,998	7.6	14.6
100	13,531	8.4	15.8

Hydraulic evaluations of stage versus discharge for storms with recurrence intervals of 2, 5, 10 & 25 years, at five discrete locations with surveyed cross-sections were prepared by Monroe (2002). Storm flows were based on regression equations of Thomas et al. (1994), which yield estimates similar to those of Loomis (1994). Based on data from nearby gaged watersheds, 1-yr-duration proxy hydrographs that included these storms were prepared and Monroe estimated sediment transport capacity at the 5 locations. As can be anticipated, floods have the potential to move large quantities of sediment at those cross-section locations with a large percentage of relatively fine-grained bed material.

A water surface and moveable-bed sediment transport model (HEC-6, provided by the U.S. Army Corps of Engineers) was prepared by Schlinger et al. (2002; 2003) to assess probable sediment transport for the following Fossil Springs Diversion Dam decommissioning scenarios:

- ❑ Full removal of the diversion dam;
- ❑ Removal of 6 feet off the top of the diversion dam;
- ❑ No removal of the diversion dam.

The simulation considered a reach that extended from nearly 1200 feet upstream of the dam to 350 ft downstream. The results of that study must be set in the context of FERC's subsequent October 8, 2004, license surrender order (FERC 2004b) that the Fossil Springs Diversion Dam be lowered by 14 feet, which is a scenario intermediate between that of full removal and that involving the removal of the upper 6 feet. Under the 14-foot removal scenario:

- ❑ A drop in the water table of nearly 14 feet at the dam and in much of the sediment wedge area upstream of the dam can be anticipated.
- ❑ Over the course of a nine-month period, selected as the likely maximum duration of time that might pass without storm flows, the 46 cfs Fossil Springs base flow has minimal impact on the sediment wedge presently behind the dam.
- ❑ Seasonal flows corresponding to the 2-year summer or winter/spring storms have the potential to move significant quantities of sediment for the total removal option. Sediment volume eroded from the wedge area during the 2-yr summer event is estimated to be in the ballpark of 500-1,000 cu yd. We project sediment erosion during the 2-yr winter/spring event, of perhaps 800-1,200 cu yd.
- ❑ The 100-yr storm has the potential to remove upwards of 1/6th to 1/4, or 4,000 to 6,000 cu yd, of the total sediment wedge volume of approximately 25,000 cu yd.

Considering the 100-yr storm as a baseline event, based on the results of the HEC-6 simulations, which provide an estimate of the change in the bed profile following a storm flow, it is anticipated that erosion of the sediment wedge behind the dam will not be significant beyond a distance of approximately 600 ft upstream of the dam. Larger storms (500-year, probable maximum flood, etc.) will have impacts not yet considered with sediment transport modeling. However, bedrock control that exists at and below the dam, and in the Fossil Springs area will limit long-term downcutting.

Downstream of the dam, significant impacts are expected as the sediment wedge is eroded and transported downstream, as a ‘sediment wave’ by flood events. Over time, the peak of this sediment wave will be attenuated, and the profile of the sediment wave in the downstream channel will be stretched out over greater distance.

Water Rights

APS or its predecessor(s) has, since 1900, held a "36" water right, which is a *statement of claim of rights to use public waters of the state of Arizona* on Fossil Creek, for 31,123 ac-feet per year. The number 36 refers to the prefix assigned by the Arizona Department of Water Resources to these claims of rights. The point of diversion is the Fossil Springs Diversion Dam, and the diverted water is eventually discharged to the Verde River at Childs, 3.5 miles above its confluence with Fossil Creek. As part of the above-described decommissioning settlement agreement, APS will transfer their water rights to the Forest Service. Specifics of Arizona water law may make this transfer difficult.

In addition to the APS water right for power generation, there are several other water rights and claims within the Fossil Creek watershed. These include water right claims ("38's") for stock ponds, water rights (certificates) for domestic use from springs in the watershed for use at APS's employee housing, and water rights claims ("36's") for instream livestock use by grazing permittees.

There are also downstream water rights that rely on water discharged from Fossil Creek. Fossil Creek is a tributary to the Verde River, which is impounded by Horseshoe Reservoir and Bartlett Lake below the confluence with Fossil Creek for use by downstream water right holders. Downstream appropriators include the Salt River Valley Water Users Association (SRP), Fort McDowell Indian Tribe and cities within the Phoenix metropolitan area. The Tonto, Coconino and Prescott National Forests also have an instream flow water right certificate for a reach of the Verde River that extends above and below the confluence with Fossil Creek.

Additionally, the US Forest Service applied for an instream flow water right on December 1, 1999 (Application #33-96622) and seeks to permit a total volume of 33,305 acre-feet per year (Nelson 2003). The reach included within the instream flow application begins above Fossil Springs, approximately one half mile above the Fossil Springs Diversion Dam, and extends to the confluence of Fossil Creek with the Verde River. The short reach of Fossil Creek that flows through private property is excluded from the claimed reach.

The Fossil Creek instream flow appropriation sought by the Forest Service would not have a detrimental affect upon valid, existing, senior surface water rights because the appropriation is for an in-situ, non-consumptive use that would not reduce water available to these water right holders (Nelson 2003).

Restoration Actions and Goals

The key water- channel- and watershed-related restoration actions for Fossil Creek as a result of Childs-Irving decommissioning are:

- Restoration of the 46-cfs baseflow;

- Lowering the crest of the Fossil Springs Diversion Dam by 14 feet;

As a direct result of these actions the following restoration objective will be met:

- Riparian corridor restoration, including restoration of the travertine pool and dam complexes.

These restoration goals will require no specific actions but will follow directly from baseflow restoration. The dam crest lowering addresses Forest Service safety and maintenance concerns, and results in nearly complete removal of an artificial water control structure. Removal of 14 feet of the dam and lowering of the water table upstream of the dam will likely result in mortality of some of the riparian vegetation currently occupying the sediment wedge upstream of the dam. The above two restoration actions have implications, presumed positive, for the native fish restoration project that took place in the fall of 2004.

In addition there are several other restoration actions planned as part of the decommissioning:

- ❑ Removal of the Irving facilities;
- ❑ Removal of flumes and siphons;
- ❑ Stehr Lake regrading and revegation;
- ❑ Other lesser actions.

With the exception of the Stehr Lake actions, these other restoration actions are of minor consequence with regard to water- channel- and watershed-related restoration objectives. The Stehr Lake regrading and revegetation will remove an artificial water feature that would not otherwise exist in the Fossil Creek watershed.

Research, Monitoring and Evaluation

Restoration of the 46-cfs Fossil Springs baseflow to Fossil Creek requires no monitoring or evaluation, per se. However, the spring-supplied baseflow may, in the long term, be affected by groundwater development in the surrounding area, or by climatic or other factors. Long-term monitoring of the Fossil Springs baseflow is desirable, but it is not presently the responsibility of any party or parties. Beginning in summer, 2005, a civil and environmental engineering Master's student at Northern Arizona University will be looking at identifying and evaluating suitable locations for flow gaging in Fossil Creek. See further discussion of gaging in the following section, Spring Characterization and Groundwater.

FERC (2004b) has stipulated that, as part of license surrender and removal of project works, the Fossil Springs Diversion Dam crest will be lowered by at least 14 feet, with anticipated action in 2007. Once the crest is lowered, a significant portion, probably in excess of 50 percent, of the nearly 25,000 cu yd of sediment presently stored behind the dam will be able to move downstream in response to storm flows (Monroe 2002; Schlinger et al. 2002; 2003). This sediment movement will be accompanied by environmental and ecological impacts, both upstream and downstream of the dam, and these impacts will be monitored and evaluated. This is important because in many, if not most, dam removal actions, hypotheses and assumptions concerning sediment movement, made during planning the actions, are rarely tested and impacts are rarely evaluated.

Researchers in civil and environmental engineering at Northern Arizona University are engaged in a long-term study of sediment transport related to the above decommissioning action at the Fossil Springs Diversion Dam. It has been assumed that other decommissioning actions (Stehr Lake restoration; flume, pipeline, building removal) will have minimal affects on sediment in the channel, as these other actions will utilize best management practices (BMPs) for erosion control. However, in the case of the Fossil Springs Diversion Dam removal, sediment behind the dam will be managed by allowing intermittent storm flows to transport the sediment downstream.

Changes in sediment thickness will be monitored with a series of cross-sections and topographic surveys, both upstream (approximately 600 feet) and downstream (approx. 1600-2400 feet) of the Fossil Springs Diversion Dam. Pebble counts will also be completed to document sediment grain-size distributions. Initial monitoring to document existing, or *baseline*, conditions with respect to channel cross-section and sediment sizes began during fall 2004 and will be completed by spring of 2005. This work consists of:

- ❑ Research in stream channel morphology along the entire channel length;
- ❑ Developing channel cross sections and topographic survey data at selected locations for repeat observations;
- ❑ Pebble counts.

The results will be of value to assess sediment transport due to lowering of the diversion dam – which must, in the long term, be set in relationship to sediment transport in the watershed.

Conclusions

The hydrology and channel conditions in the Fossil Creek watershed dramatically changed in response to the Childs-Irving hydroelectric power plants coming on line in 1909, nearly a century past. The year 2005, with the restoration of the 46-cfs travertine-forming baseflow, is truly a 'watershed' year in this remarkable corner of Arizona.

With the flow restoration, the stream hydrology will change dramatically, as far as the dramatic increase in baseflow that will result. The flood hydrology will change little, as flood peaks are large compared to baseflow. We fully anticipate that travertine formation will resume – at rates and with dam and pool distribution similar to what existed before 1909. Channel modifications will result from increased travertine formation and from changes in the riparian plant community in response to the change in wetted perimeter from the persistent 46 cfs baseflow.

In the latter years of the decommissioning process, c. 2007 or 2008, the planned 14-ft lowering of the Fossil Springs Diversion Dam will produce dramatic changes in the vicinity of the dam. Upstream of the dam, the sediment wedge will begin to erode in response to sediment transport by infrequent high-magnitude storm events. Downstream of the dam, this sediment will be deposited, in existing pools, in bank areas, and behind newly formed/forming travertine dams. Within a period of several tens to several hundred years, a new dynamic equilibrium will take hold – one that we expect to be similar to that which existed prior to 1908.

Spring Characterization and Groundwater

Abe Springer

Introduction

Springs form the headwaters or sources of water for many watersheds in the Western United States. Even though Arizona has the second highest density of springs of any state west of the Mississippi River, it is estimated that more than half of them are not located or characterized (Springer et al. 2004). The discharge from springs in the Verde River watershed such as Fossil Springs is an essential contribution to the surface-water of the watershed. Groundwater conditions in the region effects the resulting discharge from these springs.

Fossil Springs is one of the few remaining unmanipulated major springs left in the West, and provides insight into the natural function of a critical keystone ecosystem. Springs are important because: 1) they provide critical water and food resources for wildlife and recreation; 2) they are important point sources of biodiversity and productivity in otherwise low productivity desert landscapes; and 3) they are the focus of human activities, regional history, and land and wildlife management (Springer et al. 2004). Unfortunately, springs ecosystems such as Fossil Springs are highly threatened by human activities.

Fossil Springs has a discharge which is greater than any spring complex outside of the tributaries of the Colorado River in Grand Canyon. Compared to the major springs of the Grand Canyon (Blue Springs, Havasu Springs, and Tapeats Springs), Fossil Springs is of nearly the same order of magnitude of discharge. Without this perennial discharge from the spring complex, there would not be the unique and important aquatic ecosystem in Fossil Creek or the spectacular travertine complexes.

Fossil Creek is an intermittent stream from its headwaters at the confluence of Sand Rock and Calf Pen Canyons to Fossil Springs, flowing in response to summer thunderstorms, widespread frontal storms and snowmelt runoff (Nelson 2003). Perennial flow in Fossil Creek begins where a complex of springs emerge over a 1,000 foot reach of the creek that ends approximately 1,000 feet upstream of the Fossil Springs Diversion Dam.

Fossil Springs discharge from the bottom of the Naco Formation (Upper Middle Pennsylvanian age) at the contact of the Redwall Limestone in Fossil Creek (Figure 6). The Naco Formation is present along the Mogollon Rim east of Fossil Creek and consists mainly of limestone and mudstone. The springs discharge in a canyon which has incised through a thickness of about 3,000 feet of sedimentary and volcanic rocks (Figure 6). Rainfall and snowmelt infiltrate through these rocks on higher elevations of the Mogollon

Rim and flow through faults and fractures to eventually discharge through the multiple spring orifices in the Fossil Springs complex.

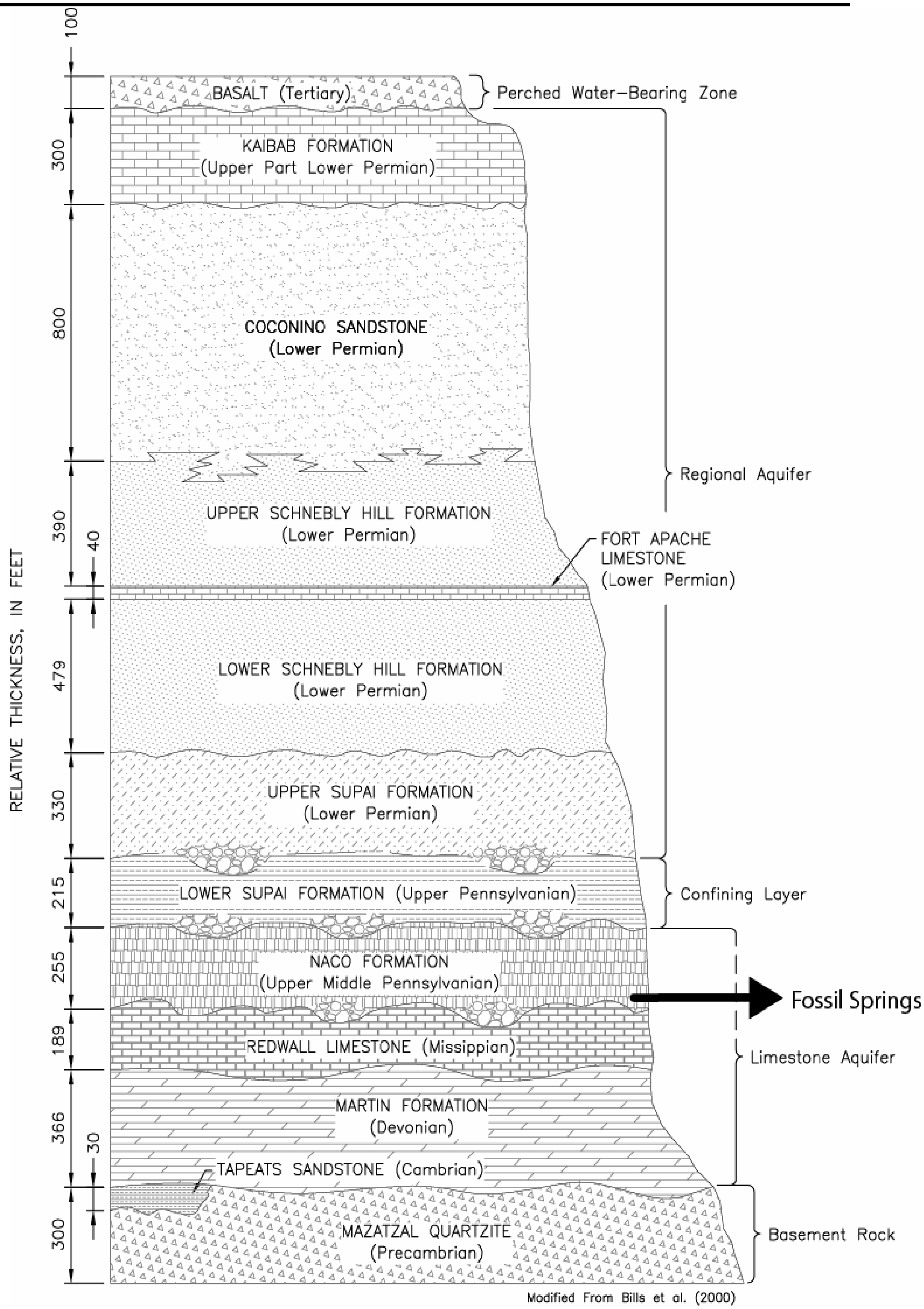
General Trends

Continuous gauged spring discharge data for Fossil Springs are not available and have never been collected. The USGS gage on Fossil Creek (Fossil Creek Diversions to Childs Power Plant, Near Camp Verde. AZ, gage No. 09507500) was for the diversion on the flume from Irving to Stehr Lake, not for the flow within the channel. It did not record flows discharged from Irving to the Fossil Creek channel (estimated at 2-5 cfs) or flood flows down the mainstem of Fossil Creek (Nelson 2003). Discharge from the springs in the Fossil Springs complex was measured sporadically till 1999 when the USFS began measuring discharge monthly for an instream flow right (Nelson 2003) (Figure 7).

Discharge of the springs is not constant and varies seasonally and potentially annually (Nelson 2003) (Figure 7). Spring discharge has been measured to vary between about 40 and 54 cfs. There is a slight, but not statistically significant ($r^2 = 0.16$), decline of discharge over the period of record. Discharge may be responding to reduced recharge from current drought conditions with a diminished winter low flow trend over the past 5 years. Because there are little to no groundwater withdrawals from wells tapping the aquifer which supplies Fossil Springs, it is unlikely that recent groundwater pumping is influencing spring discharge. A survey of 160 springs in the Middle Verde River Watershed in 2002 found that nearly 50 % of the springs were dry in response to the dry climate conditions from 1995 to 2002 (Flora 2004).

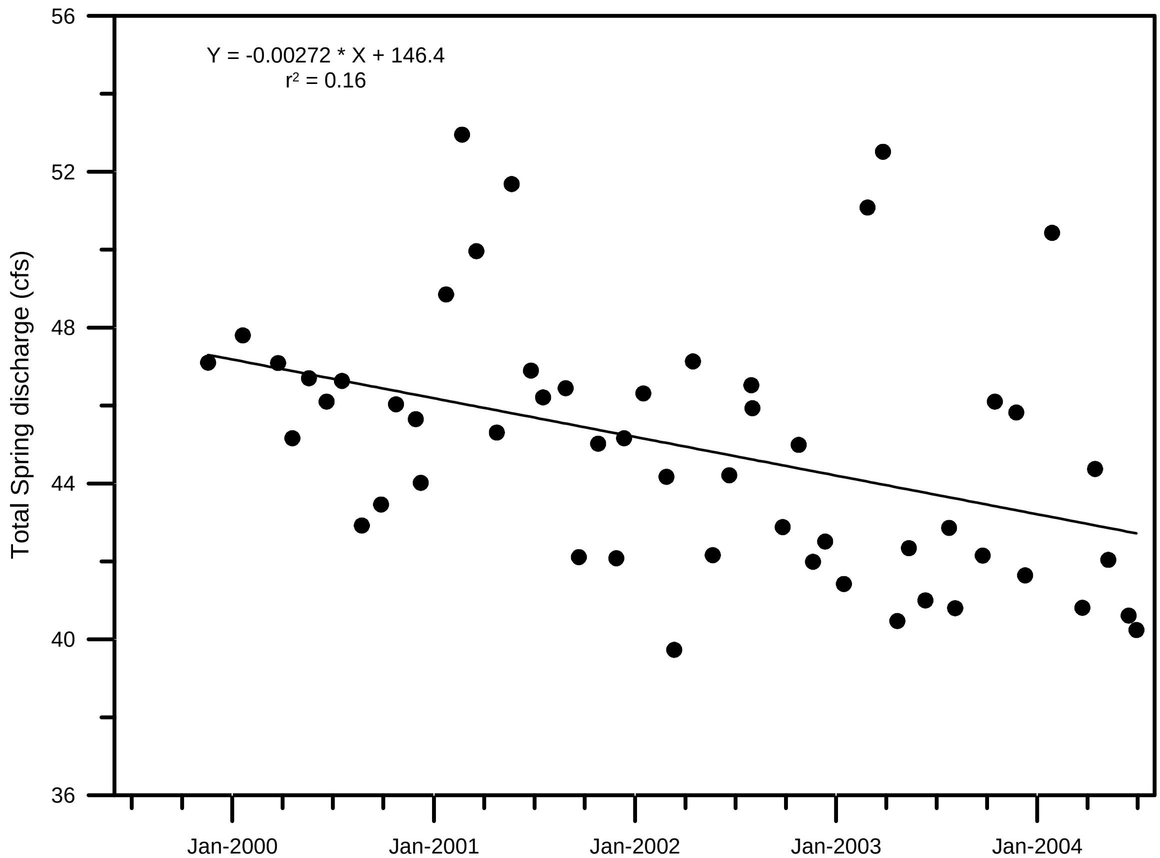
All previous discharge measurements for Fossil Springs have been for total, aggregate discharge from each individual spring orifice in the spring complex. Reconnaissance surveying in 2004 as part of this study indicated that there are over 60 individual spring orifices at Fossil Springs, discharging between a few gallons per minute and 10 cfs. The individual spring orifices of Fossil Springs have never been located or characterized, but are being located as part of ongoing studies.

Figure 6 (next page). Generalized stratigraphic section for the Pine/Strawberry/Fossil Springs area (Kaczmarek 2003).



100
BASALT (Tertiary)
Perched Water-Bearing Zone
300
KAIBAB FORMATION
(Upper Part Lower Permian)
800
COCONINO SANDSTONE
(Lower Permian)
Regional Aquifer
390
40
UPPER SCHNEBLY HILL FORMATION
(Lower Permian)
FORT APACHE
LIMESTONE
(Lower Permian)
RELATIVE THICKNESS, IN FEET
479
LOWER SCHNEBLY HILL FORMATION
(Lower Permian)
330
UPPER SUPAI FORMATION
(Lower Permian)
215
LOWER SUPAI FORMATION (Upper Pennsylvanian)
Confining Layer
255
NACO FORMATION
(Upper Middle Pennsylvanian)
Fossil Springs
189
REDWALL LIMESTONE (Missippian)
Limestone Aquifer
366
30
MARTIN FORMATION
(Devonian)
TAPEATS SANDSTONE (Cambrian)
300
MAZATZAL QUARTZITE
(Precambrian)
Basement Rock
Modified From Bills et al. (2000)

Figure 7. Point measurements of cumulative discharge of all springs discharging from Fossil Springs complex from 1999 to 2004 (Nelson 2003; unpublished USFS and NAU data).



Restoration Goals

Unlike the aquatic ecosystems of Fossil Creek which will be restored when diversion ceases, the springs of Fossil Creek will not be influenced by restoration activities below the diversion dam. The impacts to the sources of water for the springs are from changes to recharge and groundwater withdrawals from the large regional aquifer which supplies the springs. The goal of management for the springs of Fossil Creek is to sustain a baseflow of spring discharge necessary and sufficient to maintain the associated aquatic and riparian ecosystems, and the travertine processes. A request to maintain baseflow in Fossil Creek is part of the U.S. Forest Service instream flow assessment (Nelson 2003).

Monitoring

All of the planning for future management of Fossil Creek assumes the quality and quantity of water discharging from Fossil Springs are unchanging. Climate change, land management changes that affect recharge, or pumping of water from the aquifer all have the potential to affect this assumption of unchanging quality and quantity of the water discharging from Fossil Springs. There is a critical need to establish a gauging station on Fossil Creek immediately downstream of the last spring orifice to monitor trends in the baseflow of Fossil Springs.

Once the individual spring orifices have been located and characterized as part of ongoing studies, it will be possible to identify and track changes to their location or discharge through time. Although comprehensive biological surveys have not been completed, it is likely that specific microhabitats and specific species are dependent on each of the over 60 individual spring orifices in the spring complex.

After finishing baseline characterization of the individual spring orifices which contribute to the total discharge of the Fossil Springs complex, NAU will build a three-dimensional hydrogeologic framework model for the aquifer which contributes flow to Fossil Springs. The framework model will serve as the base for future numerical groundwater flow models for Fossil Springs which can help understand how changes in management to the aquifer or the watershed may influence the quantity and quality of water discharging from the springs.

Indicators

Critical to indicating the baseflow of the springs of Fossil Creek is the establishment of a gauging station on Fossil Creek downstream of the springs. Once the gage is established, it would be possible to start developing correlations between quantities of discharge from the springs and the rates and amounts of travertine formation, and the health of the associated riparian and aquatic ecosystems. As has been done for other riparian and aquatic ecosystems, it may be possible to establish the necessary and sufficient discharge conditions to sustain the unique aquatic and riparian systems in Fossil Creek. Once these conditions are established, it would be possible to inform groundwater management decisions for the aquifer associated with Fossil Springs. This gauging data will be invaluable to the construction and calibration of numerical groundwater flow models for the aquifer. Also, once the individual spring orifices are located and characterized, it will be possible to monitor their response to climatic and other changes through time. If the number of orifices or the rate of discharge of individual orifices changes through time, it will be possible to gain insight into the changes to baseflow of the stream and condition of the aquifer.

Water Quality
Abe Springer

Introduction

Fossil Springs emit water supersaturated with respect to $CaCO_3$ which create travertine features that dramatically influence the stream morphology. These travertine features are formed by an unusal combination of natural processes (Malusa et al. 2003). Elevated levels of CO_2 in the aquifer from various processes lead to supersaturation with respect to $CaCO_3$. Because one of the sources of CO_2 may not be meteoric, but from deep earth crustal processes, this may lead to some of the unique water quality characteristics of Fossil Springs.

General Trends

In June 2004, water samples were collected from three separate spring orifices in the Fossil Springs complex to determine if there were any differences in water chemistry between individual orifices. Water discharging from Fossil Springs is a Calcium-Bicarbonate type water (Table 9). The total dissolved solids concentrations are between 650 and 700 mg/L. Arsenic concentrations are between 5 and 7 µg/L. There appear to be no significant chemical differences between the water discharging from individual spring orifices, but this will continue to be investigated.

For comparison, samples collected at the springs (unknown which spring orifice) by Malusa et al. (2003) in March 1996 and Feth and Hem (1962) are listed in Table 9. APS (1992) collected water quality data from November 1989 and 1990 as part of the application for new license for major project, existing dam. A sample collected at the springs (unknown orifice) indicated a dissolved oxygen content of 7.9 ppm, a pH of 7.53, an electrical conductance of 810 umhos/cm and a temperature of 69° F.

Table 9. Summary of chemical analyses from water collected from various spring orifices in Fossil Springs in June 2004, Malusa et al. (2003) and Feth and Hem (1962) (all units mg/L unless noted otherwise).

Orifice	K	Na	Ca	Mg	Cl	SO_4	H_2CO_3	HCO_3	As (ug/L)
Upper Left	2.00	10.70	92.0	36.5	8.03	23.57	185.8	340.6	6.98
Upper Right	1.70	10.05	86.0	34.0	8.80	25.42	161.8	332.7	5.18
Fig Tree	1.95	10.80	87.5	34.5	7.99	23.60	163.7	328.8	5.43
Malusa et al. 2003	1.5	11.9	102.6	38.5	8.9	29.4	99.0	466.1	---
Feth & Hem 1962	34 (K+Na)		56	34	8	2.9	---	370	---

K = Potassium, Na = Sodium, Ca = Calcium, Mg = Magnesium, Cl = Chloride, SO_4 = Sulfate, H_2CO_3 = Carbonic acid, HCO_3 = Bicarbonate, As = Arsenic

In conjunction with Laura J. Crossey, Karl Karlstrom, and Dennis Newell of the Department of Geology, University New Mexico, NAU has been examining the geochemistry of travertine-depositing springs of the Arizona Transition Zone (which includes Fossil Springs). Travertine-depositing springs located in the Colorado Plateau region of the southwestern U.S. are hypothesized to be genetically linked to mafic magmatism and extensional tectonics, providing a window into a previously unrecognized component of deeply circulated hydrothermal fluids influencing groundwater. Active springs are commonly located along deep, basement rock-penetrating faults and associated with large accumulations of Quaternary travertine deposits, implying that these hydrologic systems have persisted through long-periods of geologic time. Preliminary sampling for aqueous and gas geochemical tracers was undertaken with Abe Springer and NAU students in summer 2004 to see whether springs of the Arizona Transition Zone exhibit the same features as those found for travertine systems of the Grand Canyon region. Preliminary major ion and trace element analyses along with SO_4, Cl, Br (bromine), HCO_3, $\delta^{18}O$, Sr (strontium), and $^{87}Sr/^{86}Sr$ analyses will be used to trace the origins of travertine-depositing spring waters. Springs in the Colorado Plateau region fall on a trend between dilute and very saline end-members.

Analysis of dissolved gases within the spring waters is underway. Preliminary examination suggests a mixing trend between atmosphere/soil gas with an end-member dominated by CO_2 (carbon dioxide) (high CO_2/N_2) (N_2 = nitrogen) gas compositions range to over 99 volume % CO_2 in some springs. Trace gas analyses shows elevated He concentrations (low N_2/He) in some springs suggestive of a deep origin for the gases. $^3He/^4He$ analysis demonstrates the presence of mantle-derived He component in travertine-depositing springs (Fossil Creek and Montezuma Well), likely associated with magmatic CO_2.

Restoration Goals

Although the chemistry of the water from Fossil Springs will not be influenced by the dam decommissioning and the return of flows to the channel, changes in geochemical processes in the aquifer which supplies the springs may influence the water chemistry. Increases or decreases of recharge to the aquifer, which might lead to changes in the volume of water stored in the aquifer, may lead to changes in residence time, and subsequent changes in chemistry.

Monitoring

Because changes in the chemistry of water from Fossil Springs is influenced by factors external to the actions below the springs, it will be essential to establish a baseline monitoring program to detect any changes in water chemistry. This baseline monitoring should include major cations and anions to examine the change in carbonate chemistry and the potential for changes in travertine formation. The monitoring should also include other dissolved constituents important for determining any impacts to the associated aquatic ecosystem. Samples for chemical analysis should be collected at the location of the spring discharge gauging station.

Indicators

When relationships between the discharge of Fossil Springs and the rates of travertine formation are determined, it will be possible to use the long-term monitoring of spring discharge and water quality to determine if there are any important changes in the rates of travertine formation. Rates of change of travertine formation caused by changes in spring discharge could alter the number and height of dam/pool travertine complexes, altering the aquatic habitat.

Vegetation[6]

Daniela Roth

Eight biotic communities have been documented from the Fossil Creek – Lower Verde River 5th code watershed: chaparral, desert scrub, grassland, mixed conifer, pinyon/juniper, ponderosa pine, ponderosa pine/Gambel oak and riparian, totaling 203,715 acres (USDA Forest Service 2003a; Table 10). The Fossil Creek area is distinguished by its extensive riparian areas, numerous springs, Stehr Lake and the Fossil Springs Botanical Area.

Table 10. Acres of eight biotic communities within the Fossil Creek – Verde River 5th Code Watershed and the Fossil Creek Planning Area (USDA Forest Service 2003a). ***.*** *The Fossil Creek Planning Area roughly corresponds to the Fossil Creek Watershed boundary used in this report (see Figure 5).*

Biotic Community	**Acres Within 5th Code Watershed**	**Acres Within Planning Area**
Chaparral	4,686	0
Desert Scrub	15,811	508
Grassland	4,432	685
Mixed Conifer	6,702	4,288
Pinyon Juniper	128,483	28,031
Ponderosa Pine	17,429	1,121
Ponderosa Pine/Gambel Oak	5,138	139
Riparian	18,108	1,460
Total Acres	203,715	36,260

The dominant community in the Fossil Creek – Verde River 5th code watershed is pinyon/juniper (128,483 acres), followed by riparian, ponderosa pine and desert scrub. Due to the elevational changes between Fossil Springs (4100 ft) and the confluence at the Verde River (2600ft), the vegetation of the upland canyon slopes changes from pinyon/juniper at Fossil Springs to desert scrub below Irving (Goodwin 1980).

The dominant upland vegetation near the Childs Power Plant consists of prickly pear (*Opuntia engelmannii*), velvet mesquite (*Prosopis glandulosa*), catclaw acacia (*Acacia greggii*), buckhorn cholla (*Opuntia acanthocarpa*), and paloverde (*Cercidium microphyllum*). As elevation increases within the Fossil Creek Planning Area, the dominant vegetation includes velvet mesquite, catclaw acacia, prickly pear, shrub live-oak (*Quercus turbinella*), desert ceanothus (*Ceanothus greggii*), pinyon pine (*Pinus edulis*), one-seed juniper (*Juniperus monosperma*), Utah juniper (*Juniperus osteosperma*), banana yucca (*Yucca baccata*), and golden-flowered agave (*Agave chrysantha*). At the highest elevations, pinyon pines increase in dominance within the Fossil Creek Planning Area, and mormon tea (*Ephedra viridis*), birch-leaf mountain mahagony (*Cercocarpus montanus*) and pointleaf manzanita (*Arctostaphylos pungens*) are common (Baker Engineering 2002a).

Fossil Springs Botanical Area is located above Fossil Springs Diversion Dam and is adjacent to the Fossil Springs Wilderness. The area encompasses about 50 acres and consists of both riparian and upland vegetation (pers. comm., B. Phillips, Forest Service Zone Botanist, 2005). Fossil Springs Botanical Area was given Special Management Area status by the U.S. Forest Service due to its unique natural value including many springs and intact riparian forest. A total of 166 species of plants has been recorded from the Botanical Area (USDA Forest Service 2003a; see Appendix A of this report for a full listing).

Three hundred fourteen species of flowering plants and ferns from 77 families have been documented from the Fossil Creek Planning Area (USDA Forest Service 2004). However, a full inventory of the Fossil Creek – Verde River 5th code watershed has not been completed.

Riparian Areas

The riparian zone along Fossil Creek is dominated by deciduous trees. Tree diversity is good throughout but there are differences in overstory dominance between the reach above the Fossil Springs Diversion Dam to the reach below the dam (Sayers 1998). Seedlings are the most common age class among riparian trees at Fossil Creek, generally found in a narrow band along the creek. The number of riparian species decreases with horizontal distance away from the stream bank in direct proportion to decreasing soil moisture availability (APS 1992).

The Fossil Creek riparian area has been divided into 5 different sections for management purposes (USDA Forest Service 2003a). Zone 1 is located above Fossil Springs where stream flow is intermittent. In this area riparian vegetation is sparse and low in diversity with scattered Arizona sycamores (*Platanus wrightii*) dominating the riparian trees. Riparian trees generally show a good age class distribution. The understory is comprised mostly of upland species and is very sparse. Zone 2 consists of the intact riparian corridor from Fossil Springs to the Diversion Dam. Species diversity of riparian tree species is high and with a good age class representation. Fossil Springs Botanical Area is located within this zone. Ash (*Fraxinus velutina*), alder (*Alnus oblongifolia*) and Arizona walnut (*Juglans major*) dominate the riparian areas above the dam (Sayers 1998). Other tree species occurring throughout the riparian area are boxelder (*Acer negundo*), Arizona sycamore, willow (*Salix* sp.) and netleaf hackberry (*Celtis reticulata*). Grasses and ferns are the second most prominent group of plants in this zone, followed by shrubs and other herbaceous vegetation. The understory above the Fossil Springs Diversion Dam also contains a variety of shrubs, including chokecherry (*Prunus virginiana*), New Mexico locust (*Robinia neomexicana*) and smooth sumac (*Rhus glabra*). Introduced and invasive blackberry is increasing and becoming more dominant, especially at several of the spring sources (pers. comm. Cecilia Overby to Michele James).

Below the Fossil Springs Diversion Dam begins the compromised riparian zone, impacted by water diversion from the streambed since the construction of the dam in 1916. Zone 3 begins below the Fossil Springs Diversion Dam, where the substrate type shifts to a higher percentage of bedrock and although there is some deposition of alluvium, there is little soil to support understory vegetation (Sayers 1998). In this zone overstory dominance shifts to Arizona sycamore (Goodwin 1980). Other dominant tree species below the dam are velvet ash, Arizona alder and cottonwood (*Populus fremontii*) (Sayers 1998). Of lesser dominance are boxelder (*Acer negundo*), willow (*Salix* sp.) and netleaf hackberry (*Celtis reticulata*). Tree cover is higher than above the dam and mature trees represent the majority in the age class distribution (Goodwin 1980; Sayers 1998). The reach contains no shrubs. Grasses and ferns comprise the majority of the understory while herbaceous vegetation is the least dominant life form (Sayers 1998). Zone 4 begins below the Irving Power Station and ends downstream at the beginning of the "narrows". In this zone, well developed riparian vegetation occurs only in association with springs (Goodwin 1980). The substrate in this zone consists mostly of bedrock but localized sand bars support extensive cottonwood reproduction (Goodwin 1980). Zone 5 includes the narrows and the riparian area downstream to the confluence with the Verde River. The narrows consist of a narrow canyon with sheer walls and little stream banks. Therefore, this section of the creek supports little or no riparian vegetation (Goodwin 1980). Past the narrows, the floodplain broadens and becomes less steep. Within one-half mile of the Fossil Creek confluence with the Verde River, riparian vegetation becomes sparse and poorly developed, likely due to a large cobble/small boulder component in the substrate adjacent to the channel and the increased potential of flooding (Sullivan and Richardson 1993). At the confluence with the Verde River, widely scattered ash, hackberry and sycamore characterize the riparian area. These trees are widely scattered and only near the Childs Power Plant a good stand of deciduous trees is present (Sullivan and Richardson 1993). Downstream from the Fossil Creek confluence the floodplain is broad and dominated by seep willow (*Baccharis salicifolia*). Emergent vegetation is lacking and the overall vegetation density is low (Sullivan and Richardson 1993).

Stehr Lake was once a 23-acre regulating reservoir which has now been reduced to 3 acres of surface water due to sediment accumulation and dense growth of emergent vegetation such as cattails (*Typha* sp.) and Torrey's rush (*Juncus torreyi*). Currently, cattails occupy 13 acres of the former reservoir bordered by Torrey's rush. The northeast part of the lake is beginning to dry up and the cattails and rushes are replaced by drier site riparian vegetation. Deciduous hardwoods are scattered throughout and the lake is surrounded by willows, ash, mesquite, cottonwoods, walnuts, shrubs and grasses (USDA Forest Service 2000).

In addition to Fossil Creek, Stehr Lake, and the Verde River, there are several other riparian areas within the Fossil Creek fifth code watershed. Deciduous riparian vegetation has been documented from Calf Pen Canyon, Sandrock Canyon, Tin Can Draw, Mud Tanks Draw, Boulder Canyon, Sally May Wash, Stehr Lake Wash, and Hardscrabble Creek. Only Stehr Lake Wash has perennial flows, all others are intermittent streams (USDA Forest Service 2003a). Outside of the many springs associated with Fossil Springs and the stream corridor, there are 13 other springs located within the uplands of the Fossil Creek Planning Area. Ten of these springs have been assessed for riparian condition. Of these, six support riparian vegetation, and six have perennial flow.

Rare Plants

Numerous plant surveys at Fossil Springs and along Fossil Creek have not yet documented the presence of threatened, endangered or sensitive plants (Baker

Engineering 2002b). Table 11 summarizes the rare plant species have been determined to have potentially suitable habitat within the Fossil Creek Plannning Area:

Table 11. Forest Service sensitive or listed plant species with potential suitable habitat within the Fossil Creek Planning Area (USDA Forest Service 2003a).

Species	**Status**
Aravaipa Sage (*Salvia amissa*)	Sen
Arizona Agave (*Agave arizonensis*)	ESA – E
Arizona Giant Sedge (*Carex ultra*)	Sen
Gila Rock Daisy (*Perityle gilensis var. salensis*)	Sen
Hualapai Milkwort (*Polygala rusbyi*)	Sen
Tonto Basin Agave (*Agave delmateri*)	Sen

ESA = Endangered Species Act, E = endangered; Sen = Forest Service Sensitive

Several other Forest Service sensitive species previously considered as having potential to occur in the Fossil Creek watershed have been removed from the list because no suitable habitat is found in the area or the Fossil Creek Planning Area is outside of their known distribution range; these are Chihuahua sedge, *Carex chihuahuensis,* Eastwood alumroot, *Heuchera eastwoodiae,* Flagstaff penstemon, *Penstemon nudiflorus,* and mapleleaf false snapdragon*, Mabrya acerifolia* (Baker Engineering 2002b).

Exotic Species/Noxious Weeds

Formal inventories for noxious weeds have been conducted only for the Fossil Creek Planning Area. The Fossil Creek Database has documented 42 plant species considered invasive for the Coconino and Tonto National Forests (USDA Forest Service 2003a, Table 12). No formal inventories have been conducted for the Fossil Creek firth code watershed. Since the watershed is managed by the Forest Service, noxious weed control will follow the U.S. Department of Agriculture Forest Service Guide to Noxious Weed Prevention Practices, which provides a comprehensive directory of weed prevention practices for the Forest Service to use in planning and wildland resource management activities (Baker Engineering 2002c).

Several cultivated plants are documented from the Fossil Creek Planning Area including figs (*Ficus carica*), sycamore maple (*Acer pseudoplatanus*), tree-of-heaven (*Ailanthus altissima*), bird-of-paradise (*Caesalpinia gilliesii*), Siberian elm (*Ulmus pumila*) and periwinkle (*Vinca major*) (USDA Forest Service 2004). These have likely been introduced by early homesteaders, still surviving in the area following abandonment (pers. comm., B. Phillips, Forest Service Zone Botanist, 2005)

Table 12. Invasive plant species documented from the Fossil Creek Planning Area (USDA Forest Service 2003a).

Scientific Name	**Common Name**
Aegilops cylindrica	Jointed goatgrass
Ailanthes altissima	Tree-of-heaven
Arundo donax	Giant reed
Avena fatua	Wild Oats
Bromus japonicus	Japanese brome
Bromus madritensis	Foxtail chess
Bromus diandrus	Ripgut brome
Bromus tectorum	Cheatgrass
Capsella bursa-pastoris	Shepherd's purse
Centaurea solstitialis	Yellow starthistle
Chorispora tenella	Blue mustard
Cirsium vulgare	Bull thistle
Cortaderia selloana	Pampas grass
Cynodon dactylon	Bermuda grass
Eragrostis lehmanniana	Lehmann's lovegrass
Erodium cicutarium	Redstem filaree
Festuca arundinacea	Tall fescue
Gleditsia triacanthos	Honeylocust
Hordeum murinum ssp. leporinum	Mediterranean barley (Hare barley)
Iris sp.	Iris
Lactuca serriola	Prickly lettuce
Lamium amplexicaule	Dead nettle, henbit
Lathyrus latifolius	Perennial sweetpea
Malva parviflora	Cheeseweed, little mallow
Marrubium vulgare	Horehound
Medicago polymorpha	Burclover
Melilotus officinalis	Sweetclover
Phalaris minor	Littleseed canarygrass
Plantago major	Broadleaf plantain
Prunella vulgaris	Selfheal
Rubus procerus	Himalayan blackberry
Salsola kali	Russian thistle

Scientific Name	Common Name
Solanum elaeagnifolium	Silverleaf nightshade
Sisymbrium altissimum	Tumble mustard
Sisymbrium irio	London rocket
Sonchus asper	Spiny sowthistle
Sonchus oleraceus	Sowthistle
Sorghum halepense	Johnson grass
Tamarix ramosissima	Tamarisk, Salt cedar
Tragopogon dubius	Western salsify
Ulmus pumila	Siberian elm
Vinca major	Greater periwinkle

Aquatic Habitat and Fish

Aquatic Habitat and the Fisheries Resource[7]

Mark Whitney

Aquatic habitat conditions and the associated fish communities vary along the length of Fossil Creek. Variations in habitat conditions are the result of changes in gradient, stream discharge, and stream channel substrates. The differences in fish species composition is a function of the change in habitat conditions, the influence of the Verde River fishery, both natural and man-made barriers, and introductions of non-native fish above these barriers. Personal observations and information obtained through a 2002 Forest Service stream habitat inventory provide the basis for the descriptions on fish habitat and associated species.

Aquatic habitat conditions from the springs downstream to the Fossil Springs Diversion Dam are fully influenced by and a function of, the accumulated discharge of the numerous springs. Between the springs and the Fossil Springs Diversion Dam lies a combination of cobble / small boulder riffles, shallow runs, and moderately deep pools. The fishery consists of three, and only three, native cypriniforms[8]: desert suckers (*Pantosteous clarki*), speckled dace (*Rhinichthys osculus*), and headwater chub (*Gila nigra*). All three species have been observed using the three prominent habitat types (run, riffle, pool), where the larger sized chubs are generally found in the pools. Table 13 lists all the native fish known to have occurred, or which currently occupy habitat within Fossil Creek and the associated portion of the Verde River. This table also displays species special status, occurrence within the watershed, and designated critical habitat.

Table 13. Threatened, endangered, or sensitive fishes and / or their habitat expected to occur in the Fossil Creek 5th Order Watershed.

Species	Status[1]	Occurrence[2]
Colorado pikeminnow	Endangered, WC, FS-S, T-S	O Experimental, nonessential
razorback sucker	Endangered, WC, FS-S, T-S	O Critical habitat (Verde River)
Gila topminnow	Endangered, WC, FS-S, T-S	H*
loach minnow	Threatened, WC, FS-S, T-S	H* critical habitat
spikedace	Threatened, WC, FS-S, T-S	H* critical habitat
roundtail chub	WC, FS-S, T-S	O
headwater chub	WC, FS-S, T-S	O
longfin dace	T-S, T+	O
desert sucker	T-S, T+	O
Sonora sucker	T-S	O
speckled dace	T-S	O

[1]**Status:**
T-S=Tonto NF Sensitive Species (USFS 2000)
T+=Tonto NF S&G emphasis species (USFS 1985, as amended)
WC=Wildlife of Special Concern in Arizona (1996 Arizona Game & Fish Department classification pending revision to Article 4 of the State Regulations)
FS-S=Forest Service Sensitive Species (USFS, Southwestern Region, Regional Forester's List – 21 July 1999)
[2]**Occurrence:**
O=Species known to occur in the project area, or in the general vicinity of the area.
H=Species not known to occur in the project area, but whose suitable or potential habitat does.
*****=Species have historically been known to occur in project area, no recent confirmation of presence.

From the Fossil Springs Diversion Dam downstream to the Irving Power Plant habitat conditions change rather dramatically. Diversion of virtually the entire ~43 cfs spring discharge leaves this stretch of Fossil Creek with only seepage flows. Seepage flow has been estimated at between approximately 0.2 and 1.5 cfs. A 22-foot high bedrock shelf in the stream channel creates a natural barrier (to upstream fish movement) approximately 1.4 miles upstream from the Irving Power Plant. This feature is approximately 2.4 miles downstream from the Fossil Spring diversion dam. A 10-foot waterfall approximately ½-mile downstream of the diversion dam apparently prevented upstream movement of green sunfish (pers. comm. Jerry Stefferud, to Michele James, June 1, 2005). Runs and pool / riffle complexes dominate the habitat types between the diversion dam and Irving. Cobble and boulder substrates are the dominant substrates found along the reach between the dam and the natural barrier. Bedrock lines the majority of the stream channel between the barrier and Irving. Historically, prior to the diversion of the spring flow, this length of the creek contained numerous travertine dams that formed very large and deep pool habitats. Today, only remnants of these travertine dams can be seen. Small travertine dams are present just downstream of the diversion dam. A calcite (travertine) layering covers and binds much of the gravel / cobble substrates along this length of creek, but travertine dams are virtually nonexistent. Prior to the native fish restoration project (fall 2004), the fish community along this length of the creek was comprised of desert sucker, Sonora sucker (*Catostomus insignis*), headwater chub, speckled dace, and non-native green sunfish (*Lepomis cyanellus*). The native fishes (suckers, chub, and dace) comprised the greater majority of the fish numbers nearer the diversion dam; whereas, the sunfish were more dominant nearer to Irving.

An estimated 5.5 cfs is returned to the stream channel downstream of the Irving Power Plant. Combined with the ~1.5 cfs seepage flow in the stream channel upstream of the Irving Power Plant, the ~5.5 cfs flow returned from Irving brings the total flow downstream of Irving to ~7 cfs. This increased flow has resulted in the formation of travertine dams from Irving to about three-quarters of a mile downstream of the 708 Road crossing. Some of these travertine dams are three to four feet in height, and all of them form long runs / shallow pools that intermix with low gradient riffles and deep bedrock pools. The stream channel adjacent to the Irving Power Plant contains another bedrock shelf that drops an estimated 14 feet into a large pool below. This bedrock shelf (natural barrier) marks the upstream extension of the non-native smallmouth bass (*Micropterus dolomieui*), and is possibly the transition point between the occurrence upstream of the headwater chub and the occurrence downstream of the roundtail chub (*Gila robusta*) (note: this was the condition prior to the native fish restoration project, fall 2004). In addition to the bass and chub, the fish community includes the desert and Sonora suckers, and green sunfish. The larger bass, chub, suckers, and sunfish tend to inhabit the calmer waters found in the runs and deeper pools; whereas, the smaller sized bass and the mid to large size classes of the two suckers can typically be found using the riffles. The two suckers also make use of the plunge areas on the downstream side of the travertine dams. Smaller size classes of the native species are not usually found within this length of Fossil Creek.

From that point downstream of 708 Road crossing (mentioned above) to the Verde River confluence, stream habitat types are a mix of runs, riffles, and pools. The riffles tend to be medium to high gradient, and appear to comprise the greater majority of the length of this stretch of the creek. Several sizable pools are found, but only a few exceed depths of greater than six feet. It is suspected that the upstream end of this reach contains a greater abundance of the native fish species than the downstream end nearer the Verde River. The native longfin dace (*Agosia chrysogaster*), and the non-native piscivorous[9] flathead catfish (*Pylodictis olivaris*) and yellow bullhead (*Ameiurus natalis*) were collected during a 1994 through 1996 Arizona Game and Fish Department fish survey near the Verde River confluence (Roberson et al. 1996). Continued existence of the longfin dace is questionable given occupancy by the catfish and bass species.

Allen Haden and Jane Marks

Introduction

Native fish are among the most threatened groups of organisms in the southwest, primarily because of water diversions and the introduction of nonnative fish. Over half of Arizona's fish are listed as endangered or threatened. Fossil Creek provides an opportunity for preserving native fish because it is one of a few streams in Arizona retaining viable populations of six native fish species, including headwater chub, roundtail chub, speckled dace, longfin dace, desert sucker, and Sonora sucker.

The federally endangered razorback sucker (*Xyrauchen texanus*) was stocked into the up-stream springs of Fossil Creek (Barrett and Maughn 1995; EnviroNet 1998). Razorback suckers have not recently been collected from Fossil Creek but have been collected from Stehr Lake (Sponholtz unpublished data; Haden unpublished data) and likely no longer occur in the springs area. Fossil Creek's four non-native fish – green sunfish, smallmouth bass, flathead catfish, and yellow bullhead – are most abundant in the lower portions of the stream where they likely entered from the Verde River. Nonnative fish were one of the greatest threats to native fish in Fossil Creek (Marks et al. 2003). However, in the fall of 2004, an intensive multi-agency native fish restoration effort removed nonnative fish from the upper 9 km of Fossil Creek (using a piscicide) and constructed a fish barrier on the lower end of Fossil Creek, upstream of the confluence with the Verde River.

Two potential threats to native fish following restoration of full flows to Fossil Creek are: 1) nonnative crayfish which were not negatively affected by the piscicide treatment (See Crayfish section of this report); and, 2) the release of sediments trapped behind the diversion dam which could detrimentaly affect native fish and macroinvertebrates downstream. Studies on the effects of sediments following dam removals show mixed results. In Wisconsin streams, macroinvertebrates rebounded quickly following short-term reductions following sediment release (Stanley et al. 2002). In contrast, in western streams sediments had longer lasting effects (Wohl and Cenderelli 2000; Rathburn and Wohl 2003). In Fossil Creek, the effects of sediments will depend on the capacity of the river to transport sediments and on the hydrologic regime in the first few years following sediment release (Marks et al. 2003).

Current Trends

Fish community and distributions: We have synthesized data on the distribution of fish in Fossil Creek from several sources which collected data from a common site below the Irving Power Plant. Arizona Game and Fish Department has collected data at five different sites from1994 through 1996 (Roberson et al. 1996). Tom Jones of Grand Canyon University has also collected data on Fossil Creek fish distribution from1997 through 1998. Pam Sponholtz of the U. S. Fish and Wildlife Service provided data collected from 1999 through 2001. Cody Carter of Northern Arizona University provided snorkeling observational data from below the Irving Power Plant during 2001, and the NAU Stream Ecology and Restoration Group began conducting seasonal samples in August, 2002. Fish sampling methods included backpack electrofishing, netting in deeper pools, seine netting, and snorkeling observations. Results from the NAU surveys are reported in Marks et al. (2005a) and summarized below.

Fossil Creek retains populations of fish native to the southwestern United States. Native fishes include: large minnows - headwater chub (*Gila nigra*), roundtail chub (*G. robusta*), small minnows - speckled dace (*Rhinichthys osculus*), longfin dace (*Agosia chrysogaster*), and suckers - desert sucker (*Pantosteous clarki*), and the Sonora sucker (*Catostomus insignis*) (see the following section for an overview of these species. Non-native species have also made their way into the stream, probably moving upstream from the Verde River. Green sunfish (*Lepomis cyanellus*), smallmouth bass (*Micropterus dolemieu*), flathead catfish (*Pylodictis olivaris*), channel catfish (*Ictalurus punctatus*) and yellow bullhead (*Ameiuris natalis*) have all been found in the stream. Nonnative fish increase towards the confluence of the Verde River supporting the hypothesis that they migrated upstream from the Verde River (Table 14). The section of Fossil Creek above the diversion dam contains only native fish (Figure 8). In addition, a short (<1 km) reach immediately below the diversion dam contains only native fish. The upper limit of nonnative green sunfish is a small barrier falls (~3 meters high) roughly 1 km from the diversion dam (Figure 8). Flathead catfish, channel catfish and yellow bullhead were only found at the site closest to the Verde River in our study. Green sunfish and smallmouth bass are the most predominant nonnative fish. Green sunfish were abundant in the reach from the small barrier fall to the Irving power plant before piscicide treatment in 2004. Smallmouth bass have not been found above a barrier falls at the Irving power plant (Figure 8). The invasion of smallmouth bass has been relatively recent and rapid. Grand Canyon University began finding smallmouth bass near the bridge below the Irving Power plant in 1996. Continued monitoring by Northern Arizona University at the same sites has shown that smallmouth have since become the dominant species in this area (Figure 9). Nonnatives have the greatest impact on the smaller-sized native fish. Adult dace and juvenile chubs and suckers are less common in the presence of non-native fishes (Figure 10). In contrast to bass and sunfish the three nonnative catfish have only been observed in the lower reaches of the river.

*Table 14. Distribution (presence/absence) of native and non-native fish species in Fossil Creek Data are from NAU sampling prior to piscicide treatment (2002-2004). Distribution of headwater chub (*G. nigra*) below the diversion dam is unknown since distinguishing this species from roundtail chub (*G. robusta*) in the field is very difficult. For the purposes of this table, we follow the accepted policy that all chubs Irving Power Plant are considered roundtail chubs and those above are headwater chubs.*

Taxa	Above Diversion Dam	Dam to Irving Power Plant	Irving to confluence with Verde River
headwater chub	X	X	
roundtail chub			X
speckled dace	X	X	X
longfin dace	X	X	
desert sucker	X	X	X
Sonora sucker		X	X
green sunfish		X	X
smallmouth bass			X
yellow bullhead			X
flathead catfish			X
channel catfish			X

Figure 8. Increasing dominance of non-natives in fish community composition of Fossil Creek below Irving power plant from 1996 to 2004. Data are combined from two sites which have both been monitored by Grand Canyon University and Northern Arizona University: 1996 through 1999 are electrofishing surveys conducted by Tom Jones (Grand Canyon University); 2002 is electrofishing surveys conducted by Northern Arizona University; and, 2003 through 2004 are snorkel surveys conducted by Northern Arizona University.

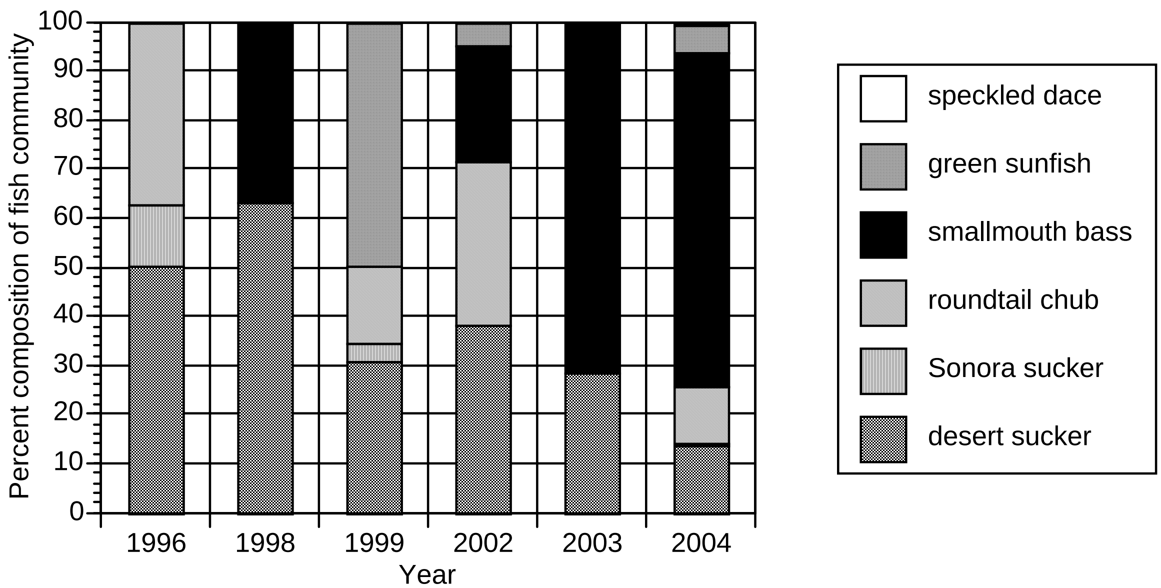


Figure 9. Fish community composition of Fossil Creek showing the increasing influence of non-native fishes downstream of the diversion dam to the Verde River. Data were collected in 2003-2004 by snorkel survey. By convention, all chubs above Irving are designated as headwater chub while all chub below Irving are roundtail chub. Figure taken from Marks et al. (2005a).

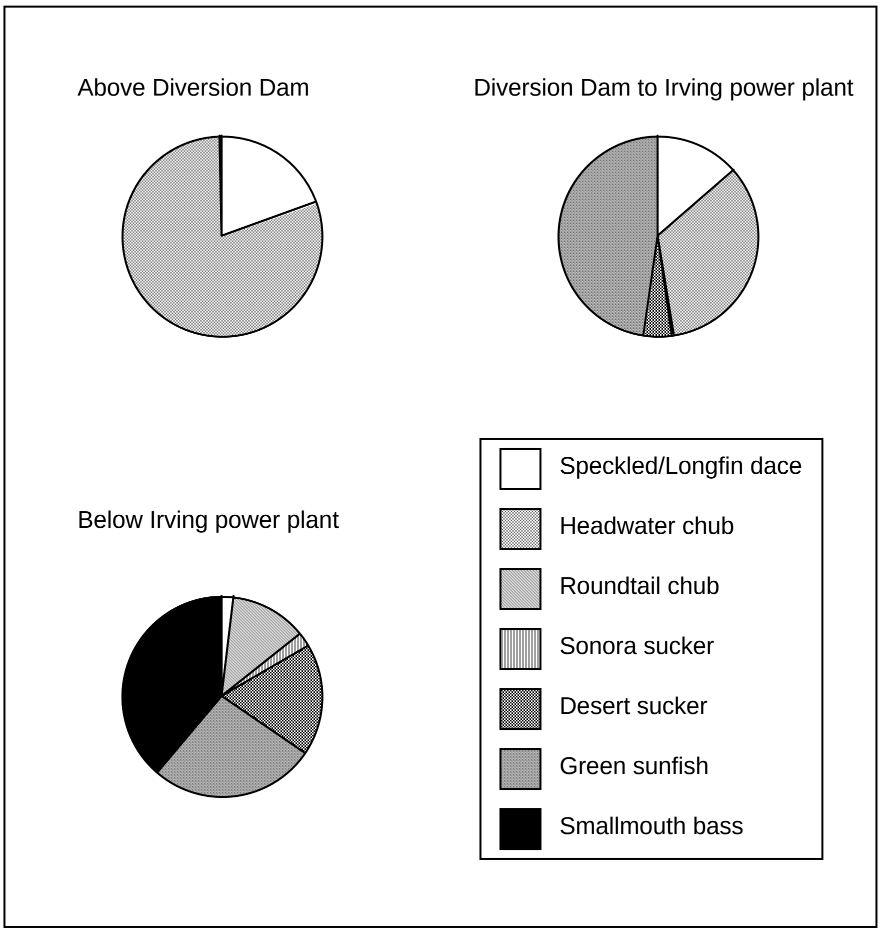
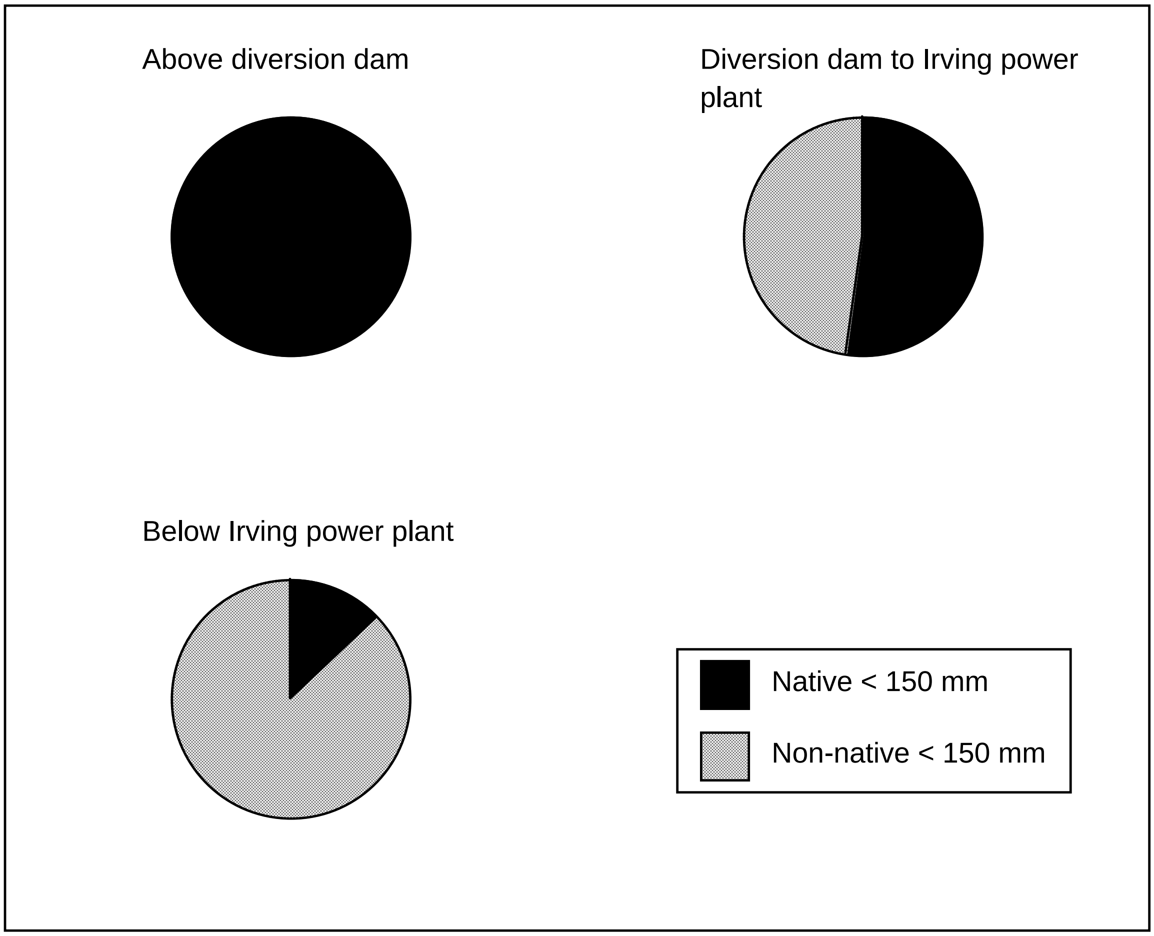


Figure 10. Fish community composition for fish <150 mm total length in Fossil Creek. Increasing relative abundance of non-native fishes is associated with a decline in small size classes of native fishes indicating poor recruitment of native fishes. Data were collected 2002-2004 by electrofishing and snorkel survey. Figure taken from Marks et al. (2005a).



Restoration Goals

1) Eradicate all nonnative fish from a 9 km reach from the diversion dam to the newly constructed fish barrier;

2) Restore and enhance the native fish population;

3) Increase recruitment of native fish; and,

4) Restore native fishes that likely ocurred pre-impoundment but have since been extirpated.

Monitoring

There is a critical need for monitoring for nonnative fish following the treatment to make sure that the constructed barrier effectively prevents upstream migration of nonnatives and to assess whether nonnatives are being transplanted back into Fossil Creek. In addition we recommend monitoring the population recovery for native fishes. Monitoring should include densities of both native and nonnative fish using the same standardized methods used in the pre-removal surveys. We expect to see an increase in native fish densities after extirpation of non-natives and with return of full flows. Research avenues that will help interpret native fish responses include quantification of invertebrate assemblages (including crayfish) and food-base standing mass, experiments studying whether native chub are able to control nonnative crayfish and stable isotope studies to test if the trophic position of native fish increases once nonnatives are removed.

Indicators

1) Presence of nonnative fish (presence shows that management objectives are not met);

2) Changes in population densities of native fish (increases show that management objectives are met, decreases show that they are not).

Special Status Fish Species' Natural History and Occurrence[10]

Mark Whitney

Information on the following threatened, endangered, and sensitive fish species is taken in part or whole from species abstracts prepared by Jerry Stefferud (Tonto National Forest Fisheries Biologist – retired) dated June 2000. This is particularly the case for those six species (roundtail chub, headwater chub, longfin dace, Sonora sucker, desert sucker, and speckled dace) identified as Tonto National Forest sensitive and management emphasis species.

Roundtail & Headwater Chubs

As moderately streamlined members of the minnow family (Cyprinidae), the roundtail and headwater chubs have a slender caudal peduncle and a deeply forked, relatively large caudal fin. Coloration of adults is silvery shading dorsally to dusky yellow or light green. Both sexes have orange-red coloration of the ventrolateral surface and on all fins except the dorsal. Both males and females possess breeding tubercles to a highly variable degree. Adult roundtails can attain 20 inches in length and two pounds in weight; whereas, adult headwater chub would be something less. Differences in fin ray counts, lateral line scale counts, and ratio of head length to caudal peduncle depth separate these two chub species.

The roundtail chub (*Gila robusta*) was included on the Regional Foresters' (USDA Forest Service – Southwestern Region) 21 July 1999 sensitive species list. Taxonomic classification for the headwater chub (*Gila nigra*) was made in 2000 (Minckley and DeMarais 2000). This classification established the distinction between the roundtail and headwater chub species. Although not officially listed as a Forest Service Sensitive Species, the status of the headwater chub, being no different from that of the roundtail, warrants the special consideration. These chub species presently occur in the Verde River Basin, which includes Fossil Creek and that portion of the Verde River associated with the analysis area. The roundtail occupies the Verde River and the lower elevation reaches of the major tributaries (Fossil Creek) to the Verde River, where the headwater chub occupies the higher elevation reaches of the tributaries.

Roundtail chub is widespread in moderate to large rivers of the Colorado River Basin. In Arizona, it still occurs in the mainstem and tributaries (Fossil Creek) to the Verde and Salt Rivers. Populations have declined considerably during the past few decades. Headwater chub are restricted in overall range to the headwater reaches of major tributaries to the Verde River.

Roundtail chub occupy cool to warmwater, mid-elevation streams and rivers where typical adult microhabitat consists of pools to eight feet deep adjacent to swifter riffles and runs. Cover is usually present and consists of large boulders, tree rootwads, submerged large trees and branches, undercut cliff walls, or deep water. Smaller chubs generally occupy shallower, low velocity water adjacent to overhead bank cover. Roundtail chub appear to be very selective in their choice of pools, as they are commonly found to congregate in certain pools, and are not found in similar, nearby pools. Spawning takes place over gravel substrate. Tolerated water temperatures range up to 80°F. Headwater chub typically use similar habitats, but existing in the headwater reaches means using smaller habitats (pools with less depth) with cooler water temperatures.

Young chubs feed on small insects, crustaceans and algal films, while older chubs move into moderate velocity pools and runs to feed on both terrestrial and aquatic insects along with filamentous algae. Large roundtail chubs take small fish, and even terrestrial animals such as lizards that fall into the water.

Roundtail chub breed in early summer, often association with beds of submergent vegetation or other kinds of cover such as fallen trees and brush, as spring runoff is subsiding. Fertilized eggs are randomly scattered over gravel substrate with no parental care.

Longfin Dace

The longfin dace (*Agosia chrysogaster*) is a small, silvery minnow (Family: Cyprinidae) that seldom exceeds 4 inches in length. Its mouth is slightly subterminal, and there is a minute barbel present on each side of the upper lip. Coloration is usually dark gray above and white below. Sides are sometimes silvery or with a dark, lateral band terminating in a black spot at the base of the caudal fin. Breeding males develop nuptial tubercles on head and fins, and may have some yellowing of lower parts and bases of paired fins.

The longfin dace occurs naturally in the Yaqui, Magdalena, Sonoyta, Gila, and Bill Williams drainages, and has been introduced into the Virgin and Mimbres rivers. It ranges from low, hot, sandy-bottomed desert streams to clear, cooler brooks in the lower reaches of the conifer zones. It is rarely abundant in larger streams, or at elevations above 5,000 feet.

It is usually found in waters less than 0.6 feet deep, with moderate velocities (1.1 feet/second) over pebble/gravel/sand substrate. Water flow is typically smooth and laminar. It has a tendency to remain in open, shallow areas throughout much of the day. The fish is highly opportunistic, moving rapidly into flowing water during periods of high precipitation and runoff to travel amazing distances in relatively short periods of time. During desiccating conditions, longfin dace persist beneath moist debris and algal mats throughout the day, then become active at night when meager flow returns. Adults tend to congregate in shaded, deep areas when water temperatures exceed 75° F. Thermal mortalities of longfin dace have rarely been observed.

Longfin dace is an opportunistic omnivore, consuming primarily insects when the preferred taxon[11] (baetid mayflies) is abundant, but consuming primarily algae when mayfly abundance is low. Other foods include detritus and zooplankton.

Most individuals become sexually mature within the first year. Spawning occurs from December through July, and perhaps to September. Saucer-shaped depressions in sandy bottom streams are used as nests, and are located along shorelines and on sandbars at depths of less than 0.6 feet. Nests sometimes are concentrated, with as many as 20 per square yard. Incubation requires about 4 days at temperatures higher than 75° F. The life span is rarely longer than three years.

Desert Sucker

The desert sucker (*Catostomus clarki*), also known as the Gila mountain-sucker, is a moderate-sized member of the sucker family (Catostomidae), reaching lengths of up to 12 inches. Its mouth is ventral with large lips, and has well-developed cartilaginous scraping edges on the jaws. The coloration is silvery tan to dark greenish above, silvery to yellowish below. During spawning, both sexes may display an orange red lateral stripe.

Desert suckers occur in the Bill Williams, Salt, Gila, San Francisco, and Verde River drainages in Arizona and New Mexico. They are characteristic of small to moderately large streams, at elevations of about 1,000 to 6,000 feet. They do not occur in reservoirs, and dams and diversions of free-flowing streams have diminished its range somewhat. The species is generally common throughout its range, however continuing threats of water development make its future uncertain.

Desert suckers are found in rapids and flowing pools of streams, primarily over bottoms of gravel-rubble with sandy silt in the interstices. Adults live in pools, moving at night to swift riffles and runs, where they feed on encrusting algae scraped from stones. Young inhabit riffles throughout the day, feeding on midge larvae. Individuals exhibit little seasonal movement, and resist downstream displacement during floods. The desert sucker is highly adaptive to a wide range of temperatures, tolerating water temperatures as high as 90° F. Desert suckers may be able to tolerate lower oxygen levels than other native stream fishes.

Chironomid larvae (midges) are the primary food of juveniles. As an adult, the desert sucker is primarily herbivorous, scraping filamentous algae from stones as well as ingesting plant detritus, aquatic insect larvae, and other invertebrates. Individuals often turn completely upside-down as they glean food off surfaces of stones.

Desert suckers spawn in late winter or early spring on riffles, where adults congregate in large numbers. Spawning is typically of one larger female and two or more smaller males. Lateral movements of the female's body form a depression in the stream channel substrates, and adhesive eggs are buried in loose gravels. Eggs hatch in a few days, and larvae gather in quiet pools near the bank, moving to swifter waters as they mature. Juveniles are mature by the second year of life at a length of 4 to 5 inches.

Sonora Sucker

The Sonora sucker (*Catostomus insignis*), also known as the Gila sucker, is a large, robust member of the sucker family (Catostomidae), commonly reaching lengths between 12 and 24 inches. Its mouth is ventral with large fleshy lips. The body is sharply bi-colored, brownish dorsally and yellow beneath. During breeding season, males develop large nuptial tubercles on their anal and caudal fins, and on the lower, posterior part of the body.

Sonora suckers are widely distributed and common between 1,000 and 6,500 feet elevation in the Gila, Verde, Bill Williams, and San Francisco River Basins of Arizona and New Mexico. It is uncommon in the upper Santa Cruz River in Arizona. Except in Aravaipa Creek, it has been extirpated from the San Pedro River in southern Arizona and northern Sonora, Mexico. The species is intolerant of reservoir conditions. Dams and diversions of free-flowing streams, water pollution, and sedimentation of streams have diminished its range, and the status of the species is uncertain.

Sonora suckers are characteristic of gravelly or rocky pools of creeks and rivers. It can be found in a variety of habitats from warm water rivers to trout streams. Adults tend to remain near cover in daylight, but move to runs and deeper riffles at night. Young Sonora suckers typically live in runs and quiet eddies. Individuals are sedentary, exhibiting little seasonal movement and resisting downstream displacement during floods.

In Aravaipa Creek, it commonly inhabits pools greater than 1 foot deep with slow current (1.0 feet/second), and with sand/gravel substrate. Information on temperature tolerances, or other habitat preferences has not been obtained.

Foods appear to vary with availability. In Aravaipa Creek it is almost exclusively a carnivore, feeding upon the abundant aquatic insect larvae (primarily mayflies) of that stream. In other places, especially where large populations are concentrated in pools in summer, intestines are filled with plant debris, mud, or algae. Seeds of cottonwood trees are taken seasonally. Young feed along the margins of streams upon tiny crustaceans, protozoans, and other animal and plant groups.

Spawning begins in February and extends till July. Eggs are deposited in riffles, and fall into the interstices between gravel particles where they incubate. Larval fish appear within a few days. Areas where suckers have been spawning may often be identified as elongated patches of "cleaned" gravel on riffles, marking the places where algae-covered bottom materials have been shifted about. Spawning does not appear correlated with any specific pattern of stream flow or temperature. Information on age and growth has not been developed.

Speckled Dace

A small minnow (Cyprinidae), the speckled dace (*Rhinichthys osculus*) seldom achieves 3 inches in length. Its body is chunky and somewhat flattened ventrally. Its mouth is slightly subterminal, with barbels present at the sides of the upper lips. Coloration is highly variable, drab olivaceous with patterns ranging from large black blotches on the body, through a single or double lateral band, to almost unicolored (darker above, lighter below). Breeding males with brilliant red on bases of paired fins and on body near those fins, on and near anal fin base, the lower caudal lobe, the mouth, and near the upper part of gill cleft.

The species is the most ubiquitous freshwater fish in the western United States, naturally occurring in all seven major drainages. In Arizona, it exists in at least two major body forms, a small, highly-speckled or blotched, chubby-bodied kind in the southern part of the Gila River system, and a larger, banded or unicolored, more streamlined kind in larger rivers and creeks to the north of the Mogollon Rim. It has been extirpated from the San Pedro River in southern Arizona and northern Sonora, Mexico, but still exists in Aravaipa Creek. It has a proclivity for small, headwater streams, often occurring in spring streams and other waters isolated by many miles of dry streambed from larger streams. This species is presently rare below about 5,000 feet elevation, but once occurred in the larger streams below that level.

The speckled dace is a bottom dwelling species that inhabits shallow, rocky, headwater streams with relatively swift flow, sometimes in areas with considerable aquatic vegetation. It is found in riffles that are about 0.5 feet deep, with water velocities of about 1.3 feet/second over pebble/cobble substrate. Adult speckled dace appear quite capable of maintaining position in streams during flash flooding, but young are carried downstream, often to their deaths in pools that later desiccate. Individuals can persist, however, for amazing periods of time in intermittent pools, although greatly crowded, diseased, and starving. Rapid, overall responses to high runoff have been recorded, in which the fish was essentially extinct during years of low discharge, but when conditions improved enjoyed high reproductive success and became abundant. Although it can acclimate to temperatures as high as 98° F, the species has a relatively low tolerance for elevated temperatures and reduced oxygen, which accounts for its peak abundance in relatively swift, moderately sized, pool-and-riffle creeks between 5,000 and 10,000 feet elevation. Preferred water temperature appears to be around 60° F.

Breeding adults seem to prefer swifter water, particularly the males, and in the late winter and early spring both sexes sometimes are numerous in swirling waters behind stones or other obstructions in the swiftest riffles. Spawning occurs in spring and again in late summer. Reproductive period is regulated by photoperiod. A single late summer flood will induce spawning whereas the same event in early summer does not. Breeding fish seek swift water where the males build the nests by cleaning the gravel clear of bottom debris and algae. Numerous males attend one female. Territoriality is exhibited with the male defending the nest. The eggs are demersal and adhesive, hatching time is six days at 65° F, and the larvae remain in the gravel interstices for about seven to eight days.

Speckled dace feed principally on benthic insects, but also takes algae, other aquatic invertebrates, and detritus.

Colorado Pikeminnow

The Colorado pikeminnow (*Ptychocheilus lucius*) was Federally listed as an endangered species, on the Endangered Species List, on March 11, 1967 in Federal Register Vol. 32 (p.4001) (USDI 1967). On July 24, 1985, the Salt River from Roosevelt Dam upstream to U.S. Highway 60 bridge and the Verde River from Horseshoe Dam upstream to Perkinsville were designated as locations for experimental, non-essential populations of Colorado pikeminnow (Federal Register 50(142):30188), meaning that their loss would not appreciable reduce the survival of the species in the wild. Those areas were subsequently stocked with the species.

The pikeminnow was once common throughout the Colorado River system, including the Gila River Basin, but natural populations are now found only in scattered areas of the upper Colorado River system in Utah, Colorado, and New Mexico (USDI 1991d). Colorado pikeminnow are believed to have ranged in the Verde River[12] up to Perkinsville, Arizona. This belief is based on bone samples taken from an archaeological site near Perkinsville (Minckley and Alger 1968). No other historic information is available to indicate Colorado pikeminnow inhabitance of the Verde River, or its tributaries within or adjacent to the Coconino National Forest (Minckley 1993).

The Colorado pikeminnow is characterized as a "big river" generalist species, occurring in turbid, deep, and strongly flowing water. However, small individuals occupy shallow backwater areas with little or no current and silt/sand substrates. Spawning occurs from early July through about mid-August, and coincides with rising water temperature and decreasing flow. Eggs are broadcast over gravel and cobble substrates in riffles or rapids. Juveniles feed primarily on insects and crustaceans, while individuals over 8 inches feed principally on fish (Minckley 1973).

Historically, the Colorado pikeminnow was the top fish predator in the Colorado River Basin, relying almost exclusively on other fishes for food once they grew past a few inches in length. The species can make migrations of several hundred kilometers to spawn in very specific canyon-like habitats. Following hatching, larvae drift downstream with the currents for up to hundreds of kilometers before settling in backwaters and initiating feeding (Tyus 1990).

The near extinction of this species is due to a combination of factors, the largest being those associated with the construction of dams for flood control, irrigation, and power development. Dams throughout the historic range of Colorado pikeminnow have altered stream morphology, flow patterns, temperatures, water chemistry, and silt loads. The dams also present migration barriers that prevent access to spawning areas.

The free flowing nature of the Verde River may provide a good opportunity for the reintroduction and/or recovery of pikeminnow in the lower Colorado River Basin. Baseline conditions of the Verde River are considered relatively good in the upper reaches above Sycamore Creek and the lower reaches below Beasley Flats (Sullivan and Richardson 1993). Habitat modifications such as stream diversions, urban development, impacts to riparian vegetation, and the predominance of nonnative fish species limit the recovery potential for the pikeminnow along the middle portion of the Verde River.

Since 1985, extensive reintroductions of hatchery-raised Colorado pikeminnow have been made into the Salt and Verde River systems. Colorado pikeminnow, although stocked annually in the Verde River near Childs, have never been captured in Fossil Creek, although in theory the species could enter lower reaches if a suitable native fish prey base reestablishes. Returns from these stocking efforts have been poor (Hendrickson 1993).

The razorback sucker (*Xyrauchen texanus*) was Federally listed as endangered, under the Endangered Species Act, on October 23, 1991 (Federal Register 56(205):54957). Critical habitat was designated on March 21, 1994 (Federal Register 59(54):13374) and includes portions of the Verde, Gila and Salt Rivers. Designated critical habitat in the Verde River extends from Horseshoe Reservoir upstream to Sullivan Lake (USDI 1994c). This species was once common throughout the Colorado River Basin, but now exists sporadically in only about 750 miles of river in the upper basin. In the lower basin, a substantial population exists only in Lake Mohave with occasional individuals occurring both upstream in Lake Mead and the Grand Canyon and downstream in the mainstem and associated impoundments (USDI 1991c).

Razorback suckers are believed to have ranged in the Verde River mainstem up to Perkinsville, based on bone samples taken from the same archaeological site as that mentioned for Colorado pikeminnow. Razorback suckers persisted in the Verde River near Peck's Lake until 1954 (Minckley 1973). There is no evidence of razorback suckers inhabiting any tributaries on the Forest, but it is speculated they may have occasionally used the lower reaches of the larger tributaries.

Razorback suckers have been stocked in numerous locations in the Gila, Salt and Verde River Basins in an attempt to recover the species. Early stocking sites on the Forest included the Verde River below Camp Verde, Fossil Creek, Oak Creek, and West Clear Creek. Reintroduction of razorback suckers into the Verde River was initiated in 1981. Returns from these early reintroduction efforts were poor. Razorback suckers were stocked above the Fossil Springs Diversion Dam in 1989 and survived for several years, but may no longer occur in Fossil Creek (Barrett 1992, Hendrickson 1992, 1993).

Information on habitat of razorback sucker is limited. Except for spawning migrations, razorback suckers are fairly sedentary, moving relatively few miles over several months. They tend to occupy strong, uniform currents over sandy bottoms, eddies and backwaters lateral to the river channels, and sometimes concentrating in deep places near cut banks or fallen trees. During spawning season, razorback suckers are found in runs with coarse sand, gravel, and cobble substrate, flooded bottom lands, gravel pits, and large eddies formed by flooded mouths of tributary streams and drainage ditches. Habitat needs of young and juvenile razorback suckers in the wild are largely unknown because researchers rarely encounter them. The diet of razorback suckers consists of midge larvae, planktonic crustaceans, diatoms, filamentous algae, and detritus.

Declines in razorback sucker populations are largely attributed to habitat modification due to water development projects similar to those described for the pikeminnow. Thus, the few remaining unaltered rivers (e.g. the Verde River) and their tributaries are vital to the continued existence of razorback sucker. Razorback suckers are also threatened by the presence of non-native species.

The Gila topminnow (*Poeciliopsis occidentalis occidentalis*) was federally listed as a endangered species, on the Endangered Species List, on March 11, 1967 (32 FR 4001). The Gila topminnow is a small member of the livebearer family, Poeciliidae. Males seldom exceed one inch in length and females two inches. Coloration is tan to olive on the body and usually white on the belly. Scales on the dorsum are darkly outlined, and the fin rays are outlined with melanophores[13], although lacking in dark spots. Breeding males are impressively blackened. Gonopodium[14] of male reaches past snout when in copulatory position. Gila topminnow is similar in appearance to western mosquitofish (*Gambusia affinis*).

Historically, Gila topminnow occurred throughout the Gila River system in southern Arizona and at the Frisco Hot Springs on the San Francisco River in New Mexico. It also occurred in most river systems through the State of Sonora, Mexico as far south as the Rio Mayo. Natural populations continue to persist in 12 sites in Arizona, and persist in several Sonoran watersheds. Recovery of the species has included introductions into approximately 175 historic and non-historic habitats across the State. These introduced populations exist in small streams and ponds in Santa Cruz, Graham, Gila, Pinal, Pima, Maricopa, Yavapai, and La Paz Counties, Arizona. Only 18 of the 175 introduced populations persist today. Fossil Creek was one of the non-historic introduction sites stocked with Gila topminnows in 1967 and 1969. This stocking of Gila topminnows into Fossil Creek has been deemed unsuccessful (Bagley et al. 1991 *in* undated paper by T. Cain, former Coconino National Forest Fishery Biologist).

Habitat requirements of Gila topminnow are fairly broad; it prefers shallow, warm and fairly quiet waters, but can adjust to a rather wide range, living in quiet to moderate currents, depths to three feet, and water temperatures from constant 80°F springs to streams fluctuating from 43-99°F. The species lives in a wide variety of water types; springs, cienegas, marshes, permanent or interrupted streams, and formerly along the edges of large rivers below 4,500 feet in elevation. Preferred habitat contains dense mats of algae and debris, usually along stream margins or below riffles, with sandy substrates sometimes covered with organic mud and debris. Gila topminnow also live in a fairly wide range of water chemistries, with recorded pH levels from 6.6 to 8.9, dissolved oxygen readings from 2.2 to 11 parts per million, and salinities from tap water to sea water.

Gila topminnow food habits are generalized and include bottom debris, vegetative materials, amphipod crustaceans and insect larvae, including mosquitoes.

The mode of reproduction in Gila topminnow is internal fertilization of the eggs with internal development of the young. The young are born alive. Onset of breeding and brood size is affected by water temperature, photoperiod, food availability, and predation. In constant warm temperature springs, breeding takes place year-round, whereas in fluctuating habitats, breeding occurs from April to August. Brood size varies from 1 to 20 young, and two broods are carried simultaneously by the female, one much further developed than the other. Gestation period is 24 to 28 days. Topminnow life span is approximately one year.

The species is declining due to the introduction and spread of exotic predatory and competitive fishes, water impoundment and diversion, water pollution, groundwater pumping, stream channelization, and habitat modification. The topminnow has been declining since the late 1800s. The loss of aquatic habitats in the southwest, due to man's activities, has been well documented. The Gila River system contains only a small fraction of its pre-1860 aquatic habitat. Major rivers were essentially perennial streams with stable channels and expensive lagoons, marshes, and backwaters. The many springs, marshes, cienegas, and backwaters formed the primary habitat for the topminnow. Channel downcutting, damming, and other manmade changes have lowered water tables changing the habitat structure of rivers and streams (U.S. Fish & Wildlife Service website – species abstract).

Loach Minnow

The loach minnow (*Rhinichthys {=Tiaroga} cobitis*) was Federally listed as a threatened species, under the Endangered Species Act, on October 28, 1986 (USDI 1986b). U.S. Fish and Wildlife Service approval of the species' recovery plan came in September 1991 (USDI 1991b). Loach minnow critical habitat was designated in 1994 (USDI 1994a), and subsequently rescinded (USDI 1998) in response to a District Court ruling on the need for analysis under the National Environmental Policy Act (NEPA). Completion of the necessary NEPA analysis resulted in the most recent designation of critical habitat (USDI 2000). In contrast to the 1994 designated critical habitat, the 2000 designation now includes segments of the Verde River, Oak Creek, Beaver/Wet Beaver Creek, West Clear Creek, and Fossil Creek. These stream courses drain National Forest lands administered by the Coconino National Forest. Critical habitat designated along Fossil Creek extends from the creek's confluence with the Verde River upstream for approximately four and seven-tenths (4.7) miles. Designated critical habitat along the Verde River extends from its confluence with Fossil Creek upstream to the Verde River / Granite Creek confluence on the Prescott National Forest (USDI 2000).

Loach minnow inhabit turbulent, rocky riffles on mainstem rivers and tributaries up to 7,200 feet in elevation. Most habitat occupied by loach minnow is relatively shallow, has moderate to swift current velocity over gravel/cobble substrates. It has been observed that the depth, velocity, and substrate of occupied habitats vary by fish age/size, seasonally, and geographically. Co-occurring native fish that inhabit riffle habitats occupied by the loach minnow are the speckled dace and the desert sucker (USDI 1991b).

Historically, loach minnow were locally common throughout much of the Gila River Basin of Arizona and New Mexico. Loach minnow distribution in Arizona included the Gila, Salt, and Verde Rivers and their major tributaries. Loach minnow populations are considered to be extirpated from the Verde River Basin (Minckley 1993, USDI 2000). The last recorded collections of loach minnow, from within the Verde River Basin, were by C.L. Hubbs in 1938. These 1938 collections came from the Verde River above Camp Verde, and from Beaver Creek near its confluence with the Verde River (Minckley 1993, Girmendonk and Young 1997). Currently, the only known loach minnow populations are in the Salt, San Pedro, Gila, and San Francisco River Basins.

Since 1987, the Arizona Game and Fish Department has conducted extensive surveys of the Verde River mainstem. Since 1994, research fisheries biologists from the Rocky Mountain Research Station have monitored seven sites on the upper Verde River. Neither of these efforts has resulted in finding loach minnow. A comprehensive listing of fish collections and museum specimens from within the Verde River Basin is given in Girmendonk and Young (1997). C.L. Hubbs' 1938 collections are the only listings that include loach minnow.

Spikedace

The spikedace (*Meda fulgida*) was Federally listed as a threatened species, under the Endangered Species Act, on July 1, 1986 (USDI 1986a). U.S. Fish and Wildlife Service approval of the species' recovery plan came in September 1991 (USDI 1991a). Spikedace critical habitat was designated in 1994 (USDI 1994b), and subsequently rescinded (USDI 1998) in response to a District Court ruling on the need for analysis under the National Environmental Policy Act (NEPA). Completion of the necessary NEPA analysis resulted in the most recent designation of critical habitat (USDI 2000). In contrast to the 1994 designated critical habitat, the 2000 designation included a much longer length of the Verde River; and newly designated reaches of Oak Creek, Beaver/Wet Beaver Creek, West Clear Creek, and Fossil Creek. These stream courses drain National Forest lands administered by the Coconino National Forest. Critical habitat designated along Fossil Creek extends from the creek's confluence with the Verde River upstream for approximately four and seven-tenths (4.7) miles. Designated critical habitat along the Verde River extends from its confluence with Fossil Creek upstream to the Verde River / Granite Creek confluence on the Prescott National Forest (USDI 2000).

Spikedace inhabits riffles and runs in shallow flowing waters over gravel, cobble, and sand bottoms. The primary habitat for adults consists of shear zones along gravel/sand bars, quiet eddies on the downstream edge of riffles, and broad, shallow areas above gravel/sand bars. Larval spikedace most commonly occupy slow-velocity waters near stream margins over sand dominated substrates. Spawning habitat for spikedace occurs in shallow riffles. It has been observed that the depth, velocity, and substrate of occupied habitats vary by fish age/size, seasonally, and geographically. Co-occurring native fish that inhabit habitats occupied by the spikedace are the loach minnow, speckled dace, desert sucker, and Sonora sucker (USDI 1991a).

Neary et al. (1996) described the physical habitat parameters used by spikedace in the upper Verde River, within vicinity of the Burnt Ranch area. Spikedace were found in greatest abundance in gradients between 0.4 and 0.6 percent, velocities ranging from 55 to 85 cm/sec (1.8-2.8 ft/sec), and in substrates of less than 10 percent sand. Depth of water appeared to have little influence on the presence or absence of spikedace. The greatest determining factor in spikedace occurrence was velocity. The species was found in only medium velocity flows, which corresponded to run and low-gradient riffle microhabitat classifications. Spikedace were absent where stream velocities averaged <50 cm/sec (1.6 ft/sec) or >90 cm/sec (3 ft/sec).

Historically, the spikedace was common and locally abundant throughout the upper Gila River Basin of Arizona and New Mexico. Its distribution was widespread in large and moderate-sized rivers and streams in Arizona, including the Gila, Salt, and Verde Rivers and their major tributaries. In the Verde River Basin, spikedace have been recorded in the lower end of WCC, in Wet Beaver Creek at the confluence with the Verde River, and also within the Montezuma Castle National Monument. The most recent occurrences of spikedace have been recorded in the upper Verde River from the headwaters downstream to the confluence with Sycamore Creek (Minckley 1993; Rinne and Stefferud – unpubl. long-term dataset – 1994 to present).

Girmendonk and Young's 1997 status review of the roundtail chub includes survey and museum collection records containing lists of fish collected from various stream reaches within the Verde River Basin. Their earliest record for West Clear Creek (WCC) is dated 1937, and notes the collection of five native fish species from a location one mile above the Verde River confluence. Spikedace were one of the five species. This reach of WCC typically dries up during the summer months, due to private land irrigation withdrawals from the creek.

Spikedace were collected in Beaver Creek in 1937 and 1938 (Girmendonk and Young 1997). No other reported collections from Beaver Creek contained spikedace. Aside from spikedace occurrences in the upper Verde River (upstream from Sycamore Canyon), this species has not been collected at any other locations along the Verde River in the recent past.

As with loach minnow, spikedace may also be extirpated from the Verde River Basin. Until recently, spikedace were thought to persist in the upper reaches of the Verde River; however, formal monitoring surveys over the past four years have failed to collect spikedace (pers. comm. J. Stefferud, B. Deason, J. Rinne; Rinne and Stefferud – unpubl long-term dataset – 1994 to present; and pers. obs.). During a 1999 survey (other than the formal monitoring mentioned above), a single spikedace was collected from a location along the upper Verde River (pers. comm. Mark Brouder, U.S. Fish & Wildlife Service).

Macroinvertebrates

Eric Dinger and Jane Marks

Introduction

Aquatic macroinvertebrates are a diverse group of organisms comprising primarily insects, snails and worms. In aquatic ecosystems, macroinvertebrates are important in transferring energy and nutrients contained in algae and leaf litter to higher trophic levels, both aquatic (e.g. fish) and terrestrial (e.g. arthropods, lizards, bats, and avian species). The aquatic macroinvertebrates of Fossil Creek are a vital link in sustaining the native ecosystem. Fossil Creek contains a particularly abundant and diverse collection of aquatic macroinvertebrates, and this diversity enhances the flow of energy and nutrients, because different macroinvetebrates eat different foods. Groups of invertebrates that consume specific types of food resources are categorized into "functional feeding groups". *Grazers* consume algae growing on rocks and travertine, *shredders* eat leaf litter, *collectors* feed on bacteria growing on leaves or bark, whereas *predators* feed on other insects. Healthy streams need representatives from different functional feeding groups to ensure proper cycling of energy and nutrients.

Current Trends:

Collections of aquatic macroinvertebrates in Fossil Creek have been ongoing since 2001. Beginning in 2002, we focused on quantitative surveys of pools and riffles in a select group of eight sites, including: the ephemeral pools, the springhead, and a riffle-pool area above the dam; sites immediately below the dam, above the power plant, and below the power plant; and downstream sites approaching the confluence of with the Verde River. Detailed descriptions of the sample sites and macroinvertebrate distributions across sites and seasons are presented in Marks et al. (2005a) and summarized below.

The diversity of macroinvertebrates in Fossil Creek is high compared to other southwestern streams (Table 15). To date, 147 macroinvertebrate species have been collected, including the endemic Fossil Springsnail (*Pyrgulopsis simplex*) and the Page Springs caddisfly (*Metrichia nigritta*) which has only been documented from Page Springs and Fossil Creek. Other surveys of southwestern streams show limited diversity, often well below 100 species (Dinger 2001, Dinger et al. 2005). Two aspects of Fossil Creek likely contribute to this relatively high diversity: 1) the springs at Fossil Creek have remained relatively pristine, with full-flows and no exotic species, presumably due to the barrier created by the diversion dam; and 2) travertine deposition in Fossil Creek promotes diversity, because travertine areas are characterized by unique insects (for more details, see Marks et al. 2005a). However, Shannon's Diversity, an index that incorporates both diversity and eveness, indicate more "balanced" assemblages in sites above the dam (excluding the ephemeral pools). Furthermore, they indicate that travertine depositing areas, along with the Above Power Plant site are not as balanced, with certain species (especially Simuliidae black flies and Hydropsychidae caddis flies) dominating the assemblage.

Table 15. Aquatic macroinvertebrate diversity measurements for Fossil Creek.

	Species Richness	Evenness	Shannon's Diversity
Ephemeral Pools	49	0.500	0.624
Springs	51	0.617	1.243
Above Dam	55	0.662	1.399
Below Dam	77	0.432	0.905
Above Power Plant	63	0.397	0.865
Below Power Plant	69	0.597	0.935
Below Bridge	46	0.628	1.027
Near Verde	50	0.439	1.081

Macroinvertebrate diversity is slightly higher above the dam than below (Marks et al. 2005a), and species richness is highest in sites with travertine deposition (Marks et al. 2005b, [Table 2]). Macroinvertebrate species distributions, biodiversity, and community structure are reported in Dinger and Marks (2002) and Marks et al. (2005a). These baseline data will be critical for evaluating how macroinvertebrates respond to restoration.

Antimycin A[15], the piscicide used during the native fish restoration project, has minimal long-term effects on macroinvertebrates if used at low enough concentrations, around 10 ppm (e.g. Minckley and Mihalick 1981). Trial studies in Fossil Creek however, indicated that relatively high doses (50 ppm) would be needed to remove exotic fish. The, amount of antimycin A applied in the Fossil Creek restoration was harmful to macroinvertebrates, causing increased numbers in the drift samples, an indication of mortality and stress. We are in the process of estimating the short term effects of this disturbance and the long term recovery rates (Dinger and Marks, unpublished data.). Both the Fossil Springsnail and the Page Springs caddisfly are concentrated above the diversion dam and were probably not affected by the antimycin treatment which was applied downstream of the Fossil Springs Diversion Dam.

Restoration Goals

Macroinvertebrates are vital to the successful restoration of Fossil Creek for two reasons. First, the native macroinvertebrate assemblage in Fossil Creek has intrinsic value due to its high biodiversity, including its two endemic species, distinct travertine community, and overall higher diversity compared to other southwestern streams (Marks et al. 2005b; Dinger and Marks 2002; Marks et al. 2003). Second, the reestablishment of a healthy aquatic macroinvertebrate assemblage is necessary for recovery of the native fish, because our ongoing stable isotope studies indicate that macroinvertebrates are a key food resource for native fish.

Monitoring

Monitoring invertebrates following flow restoration is an essential component of documenting food web and ecosystem recovery (Stanley et al. 2002). The pre-treatment data we have already gathered sets the stage for assessing the impacts of restoration activities on macroinvertebrate densities, assemblages, and distributions. We advocate repeating the sampling we have already conducted, using the same methods, and focusing on the same sites, using pre-restoration data and above diversion dam sites as controls. Future monitoring should focus on documenting changes in composition and distribution, particularly monitoring the characteristic assemblages we have already described and the species of concern we have identified (see Indicators, below).

We expect that flow restoration will promote macroinvertebrates by creating habitat directly, increasing the area of pools and riffles, and also indirectly, by promoting travertine deposition (Marks et al. 2005b). Increased flow should also enhance dispersal of invertebrates currently restricted to areas above the dam. Removal of exotic fish should also promote macroinvertebrates, by releasing them from predation pressure. On the other hand, the chemical treatment was detrimental to macroinvertebrates (Dinger and Marks, unpublished data), so monitoring their recovery will be important.

Indicators

Macroinvertebrate assemblages in Fossil Creek differ between areas above and below the dam, and between zones with and without travertine deposition. These distinct assemblages likely result from the refuge from exotic fish found above the dam, and from the unique chemical and physical characteristics of travertine, which provides important habitat for some species of macroinvertebrates. By removing exotic fish and enhancing travertine deposition, restoration should promote these characteristic macroinvertebrate assemblages. Thus, persistence and expansion of these characteristic assemblages of macroinvertebrate species will likely be the best indicators of recovery of aquatic macroinvertebrates in Fossil Creek. For example, comparing assemblages in newly-formed travertine zones to the current, remnant travertine will indicate whether returning flow helped promote native macroinvertebrate assemblages.

There are, however, certain species that should be specifically monitored and used as indicators of success or failure based on issues of concern. These include the endemic Fossil Springsnail and the Page Springs caddisfly which occur in few places and at low densities in Fossil Creek (Marks et al. 2005a). Flow restoration could increase dispersal of the Fossil Springsnail, enabling it to colonize new spring habitats along the length of Fossil Creek. In springs that currently harbor springsnails, the increased flows may increase gene flow among populations. This should be monitored. Also of concern is an exotic freshwater clam from Asia, *Corbicula fluminea*, which was initially found in lower reaches of Fossil Creek, but may be actively moving upstream. Increased flow due to restoration can be expected to mitigate their migration due to potentially higher velocities washing more of them downstream, but this also should be monitored.

Leaf Litter Decomposition

Carri LeRoy, Cody Carter and Jane Marks

Introduction

Leaf litter subsidies to aquatic ecosystems provide large quantities of energy in headwaters streams with low levels of primary productivity (Peterson and Cummins 1974; Vannote et al. 1980; Wallace et al. 1999). Leaf processing capacities in streams are controlled by two main factors: 1) litter inputs (litter quality, quantity and timing); and, 2) physical differences among streams (Webster and Benfield 1986). The energy provided by leaf litter inputs is important for the production of stream invertebrates and is transferred up the trophic chain to fish and riparian predators (e.g. spiders, birds, lizards) which often depend on aquatic insects during some of their life cycle. Estimates of the importance of detritus to Fossil Creek food webs show strong dependence on terrestrial leaf litter.

Physical factors within a stream can also alter the capacity of streams to process leaf litter. Natural stream systems have been shown to repeatedly conform to the River Continuum Concept with high reliance on terrestrial inputs at high elevations and relatively more reliance on algal productivity at lower elevations (Vannote et al. 1980). Regulated rivers, on the other hand, are thought to have this continuum reset below dams (Ward and Stanford 1983) because dams disturb natural flow patterns, and the transport of organic material downstream.

Current Trends

We measured litter processing rates for two leaf litter species (*Populus fremontii* and *Alnus oblongifolia*) above and below the diversion dam to test if reduced flow impedes decomposition (LeRoy et al. 2005). Reaches within Fossil Creek also differ in the amount of travertine deposition. Travertine deposition is expected to increase following return of full flows (Malusa et al. 2003). We compared litter processing rates for two species (*Populus fremontii* and *Platanus wrightii*) directly below the Irving Power Plant, a reach characterized with travertine dams, and further downstream where travertine deposition is not sufficient to form dams (Marks et al. 2005b). Flow is similar at the two sites. Understanding how ecosystem processes differ between high and low flow areas and between sites with and without travertine dams is useful for predicting how the ecosystem will respond to increased flow.

Leaf litter decomposition rates for both Arizona alder and Fremont cottonwood are faster above the dam than directly below the dam (Figure 11). Surprisingly, leaf litter also decomposes more quickly in an active travertine deposition reach than in a non-travertine reach (Figure 12).

Figure 11. Leaf litter decomposes faster above the dam than below it. The two species did not differ in decomposition rate at either site. Letters above treatments denote signficant differences based on pairwise comparisons. Figure taken from LeRoy et al. (2005).

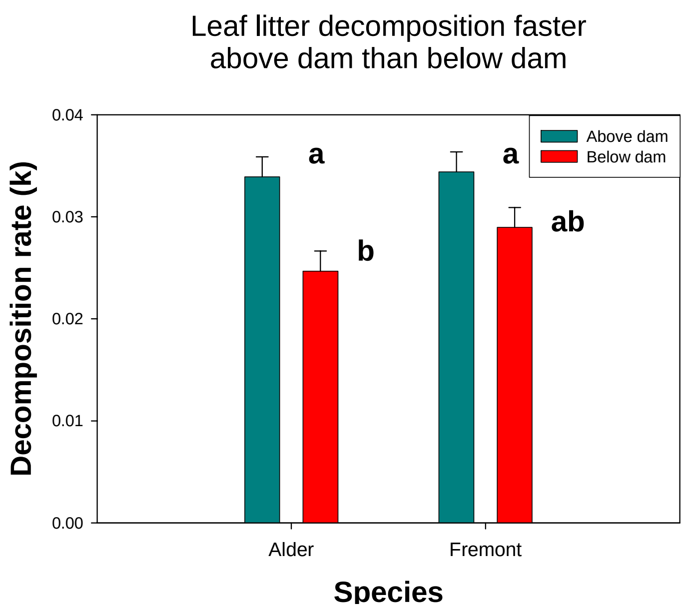
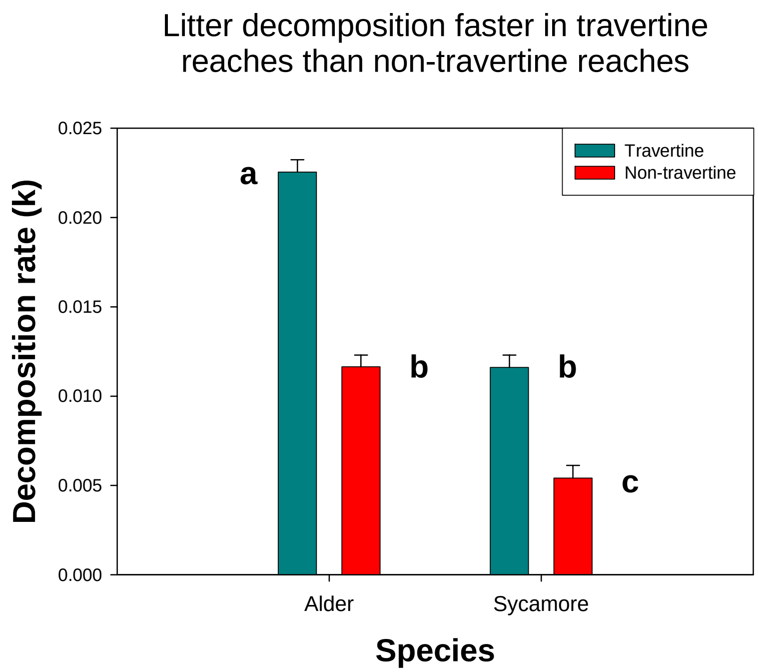


Figure 12. Leaf litter decomposes faster in travertine site relative to site further down stream. Alder decomposed more quickly than sycamore at both sites. Letters above treatments denote signficant differences based on pairwise comparisons. Figure modifed from Marks et al. (2005b) and Carter (2005).



Restoration Goals

Because fish and other aquatic species of interest rely on functioning communities and ecosystems, quantifying how dams affect ecosystem processes and determining whether restoration of flow reverses these effects is essential for determining the full potential of restoration (Poff and Hart 2002; Hart et al. 2002; Doyle et al. 2003).

Restoration of flows to Fossil Creek should result in overall higher decomposition along the currently dewatered reach because of increased area, and will return these sections of stream to a healthier amount of detrital processing. Restoration of flows, and the associated increase in available habitat will also likely increase macroinvertebrate production, providing more prey items for predatory fishes and birds along Fossil Creek. With increased discharge along its length, Fossil Creek should support a more diverse and productive riparian forest which will increase shade cover, increase habitat for terrestrial organisms and increase terrestrial inputs into the stream. Our research provides some evidence for the importance of maintaining terrestrial tree species diversity in the riparian zone of Fossil Creek.

Indicators

1) After restoration of full flows we expect to see leaf litter decomposition rates below the dam site become more similar to rates recorded above the dam site.

2) We expect the travertine deposition zone to expand and, within this zone, we expect to see higher rates of decomposition.

We are concerned that sedimentation rates will temporarily increase when the dam is lowered and these sediment loads may cause a temporary reduction in macroinvertebrate production as well as leaf litter decomposition. We are also concerned that if macroinvertebrate populations do not recover from the antimycin treatment, leaf litter processing rates may not be as high as expected.

Crayfish

Ken Adams and Jane Marks

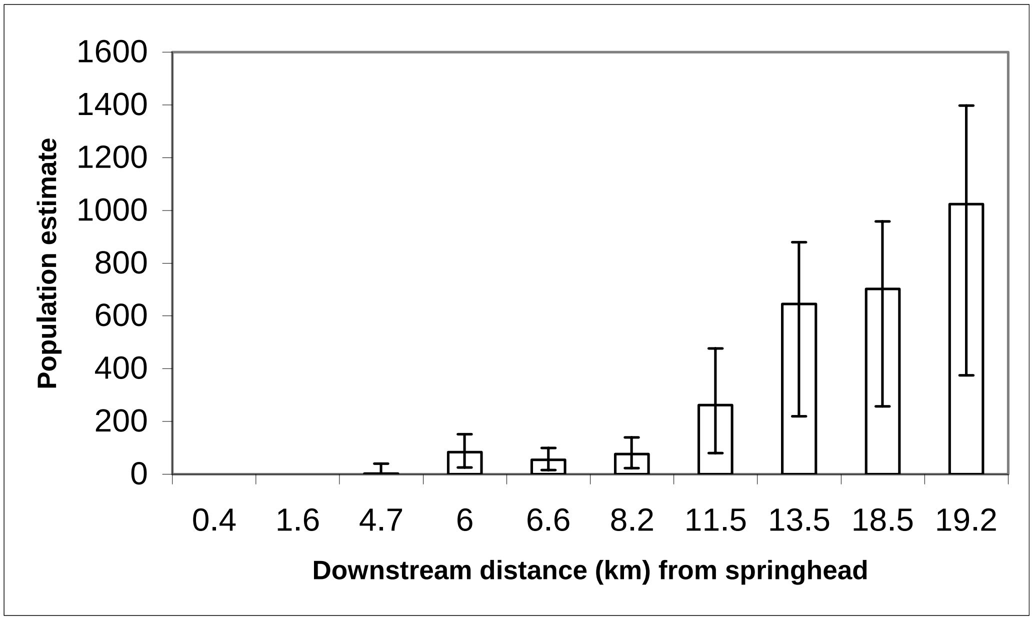
Introduction

Crayfish are notorious for invading freshwater ecosystems and initiating aggressive and complex interactions with native species (Charlebois and Lamberti 1996; Rosen and Fernandez 1996; Gamradt et al. 1997). Arizona has no native crayfish, but two exotic species were introduced by the Arizona Game and Fish Department and the U.S. Fish and Wildlife Service in the 1970s to control aquatic weeds, for sports fish forage and as bait, *Orconectes virilis* and *Procambarus clarkia*.

Current Trends

Observations of exotic crayfish in Fossil Creek date back to the 1990s. Preliminary evidence in 2003, from trapping, indicated that the crayfish *Orconectes virilis* was migrating up-stream from the Verde River, although the population has not yet established itself close to the Fossil Springs Diversion Dam. Further evidence from a series of mark-recapture studies in 2004 substantiates these findings. The density of adult crayfish in Fossil Creek ranged from 0.05 crayfish/m^2 at a distance 4.7 km downstream of the dam to 1.17 crayfish/m^2 at a distance of 18.5 km downstream (Figure 13). The biomass of crayfish at the furthest downstream site was 4.4 grams/m^2.

Figure 13. Population numbers of crayfish from ten sites down the length of Fossil Creek using adjusted Petersen estimates of mark-recapture data. Trapping data from 2003-2004 indicate a 50% reduction in catch per unit of effort at km 6.6 in 2004, possibly due to trapping from the removal efforts of Jim Walters in 2003, although there were no significant decreases at kms 6 and 8.2.



The crayfish in Fossil Creek eat a wide range of food including leaf litter, algae, and macroinvertebrates, with a preference towards macroinvertebrates, a primary food source of fish. This indicates that the crayfish have the potential to compete with native fish populations for food. Exotic smallmouth bass eat crayfish and are likely competing with them for macroinvertebrates. Thus removal of bass could inadvertently cause crayfish densities to increase. Alternatively, restoration treatments could make conditions less favorable for crayfish if increased chub populations will prey on young-of-year crayfish.

Antimycin A, the chemical used to eradicate exotic fish does not harm crayfish. There are no approved chemical methods for eradicating crayfish. The only currently available way of removing them is through manual trapping and netting, which is labor-intensive and will reduce, but not eliminate, crayfish. The NAU Stream Ecology and Restoration Group have initiated a study to test the effectiveness of different trap types on crayfish of different size classes. In addition, we will be testing for the direct effects of crayfish on macroinvertebrates and the food base under both low and restored flow.

Restoration Goals

Although it would be ideal to eradicate crayfish, more realistic goals include:

1) Preventing crayfish from establishing populations in the upper reaches of Fossil Creek where native fish are now concentrated; and,

2) Reducing population densities in the lower reaches to maintain pre-restoration levels.

Preliminary evidence from enclosure experiments suggest that crayfish will start to have significant impacts on the biological community once they reach a density of 3 adults per square meter. A current estimate of the density of adult crayfish at the furthest downstream sites is 2 per square meter.

Both of these goals could be accomplished by vigilantly trapping as long as a trapping design targets multiple size classes. Crayfish population structure is density dependent (Momot and Gowing 1977), and many crayfish removal techniques, such as trapping, are only successful at targeting larger, older adults (Bills and Marking 1988). Crayfish removal programs are further complicated by the observation that female crayfish quickly compensate for density decreases with increased reproduction via increased egg production and vitality (Momot and Gowing 1977). In order to accomplish suppression of future population density increases, a trapping program would need to target younger size classes to prevent compensatory recruitment.

Monitoring

We recommend continued monitoring of crayfish at the sites that NAU has already established. We recommend a mark and recapture protocol over standard trapping because it gives a more accurate estimate of population size.

Indicators

1) Crayfish densities – if densities are reduced or maintained then goals will be met, if densities increase goals will not be met.

2) Crayfish range – if range does not expand then goals will be met, if range extends further up stream then goals will not be met.

3) Crayfish effects on native fish recruitment – if juvenile native fish are abundant this will indicate that crayfish are not undermining their recovery in contrast if recruitment is compromised by exotic crayfish then goals will not be met.

Terrestrial Species

Janie Agyagos and Michele James

Introduction

The Fossil Creek watershed supports over 175 known species of mammals, birds, reptiles, amphibians, and terrestrial invertebrates. Terrestrial species discussed in this section include those not discussed previously under aquatic species (birds, mammals, reptiles and amphibians, and invertebrates). The number of known species in the watershed is based on actual sightings of species. There are many more species that potentially, and likely, occur in the area but have not yet been documented. The Forest Service has compiled a database of actual species documented in the area as well as species that various sources have listed as hypothetically occurring there. A query of this database shows that 298 species of mammals, birds, reptiles and frogs may occur but have not yet been documented in the Fossil Creek area.

Current Trends

Much of what is known about the terrestrial species that occur in the Fossil Creek watershed comes from the U.S. Forest Service. Information in the "current trends" sections that follow, unless otherwise noted, is from the Internal Draft Specialist Report for the Fossil Creek Watershed Planning Analysis of Affected Environment, Environmental Consequences, and Cumulative Effects for: Listed, Proposed, Sensitive, and Management Indicator Species; Neotropical Migratory Birds; and General Wildlife (USDA Forest Service 2003a).

This section is organized by species group, with a discussion of the current special status species in a given group occurring first. However, a summary of all terrestrial special status species is previewed first.

Special Status Species

Special status species include those listed as federal endangered, threatened, or candidate, as well as Wildlife of Special Concern [(Arizona Game and Fish Department 1996), Forest Service Sensitive Species (1999), High Priority Species "at risk of imperilment (Western Bat Species Regional Priority Matrix, 1998), Forest Service Management Indicator Species (MIS)[16] (from Coconino and Tonto Forest Management Plans), and Federal Species of Concern (former USFWS Category 2 species)]. Table 16 below summarizes these species; further discussion of each of these species follows under the appropriate species group.

Table 16. Threatened, endangered, sensitive, and management indicator species (MIS) for the Fossil Creek area (terrestrial species).

Common Name	Scientific Name	Status
Federally Listed (End, Thr, Proposed) (5)		
Bald Eagle	*Haliaetus leucocephalus*	T,WC,Sen,MIS
Mexican Spotted Owl	*Strix occidentalis lucida*	T,WC,Sen,MIS
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	E, WC,Sen
Yuma Clapper Rail	*Rallus longirostris yumanensis*	E, WC,Sen
Chiricahua Leopard Frog	*Rana chiricahuensis*	T, WC,Sen
Sensitive Mammals (6)		
Southwestern River Otter	*Lutra canadensis sonora*	SC, WC,Sen
Western Red Bat	*Lasiurus blossevillii*	WC, HP
California Leaf-nosed Bat	*Macrotus californicus*	WC, HP
Spotted Bat	*Euderma maculatum*	WC, HP
Allen's Big-eared Bat	*Idionycteris phyllotis*	HP
Townsend's Big-eared Bat	*Corynorhinus townsendii* (formerly *Plecotus)*	HP
Sensitive Birds (4)		
American Peregrine Falcon	*Falco peregrinus anatum*	WC, Sen
Common Black Hawk	*Buteogallus anthracinus*	WC, Sen, MIS
Western Yellow-billed Cuckoo	*Coccyzus americanus occidentalis*	C, WC, Sen
Bell's Vireo	*Vireo bellii*	Sen, MIS
Sensitive Amphibians (2)		
Lowland Leopard Frog	*Rana yavapaiensis*	SC, WC, Sen
Arizona Toad	*Bufo microscaphus microscaphus*	SC, Sen
Sensitive Reptiles (3)		
Narrow-headed Garter Snake	*Thamnophis rufipunctatus*	SC, WC, Sen
Mexican Garter Snake	*Thamnophis eques megalops*	SC, WC, Sen
Arizona Night Lizard	*Xantusia vigilis arizonae*	Sen
Sensitive Snails (1)		
Fossil Springsnail	*Pyrgulopsis simplex*	SC, Sen
Sensitive Invertebrates (14)		
Maricopa Tiger Beetle	*Cicindela oregona maricopa*	SC, Sen
Tiger Beetle	*Cicindela hirticollis corpuscular*	Sen
Freeman's Agave Borer	*Agathymus baueri freemani*	Sen
Neumogen's Giant Skipper	*Agathymus neumoegeni*	Sen
Aryxna Giant Skipper	*Agathymus aryxna*	Sen
Blue-black Silverspot Butterfly	*Speyeria nokomis nokomis*	SC, Sen
Mountain Silverspot Butterfly	*Speyeria nokomis nitocris*	Sen

Common Name	Scientific Name	Status
Obsolete Viceroy Butterfly	*Limenitis archippus obsolete*	Sen
Early Elfin	*Incisalia fotis*	Sen
Comstock's Hairstreak	*Callophrys comstocki*	Sen
Spotted Skipperling	*Piruna polingii*	Sen
Netwing Midge	*Agathon arizonicus*	Sen
Hoary Skimmer	*Libelula nodisticta*	Sen
Arizona Snaketail	*Ophiogomphus arizonicus*	Sen
Other Management Indicator Species (10)		
Yellow-breasted Chat	*Icteria virens*	MIS
Cinnamon Teal	*Anas cyanoptera*	MIS
Lucy's Warbler	*Vermivora luciae*	MIS
Lincoln's Sparrow	*Melospiza lincolnii*	MIS
Summer Tanager	*Piranga rubra*	MIS
Hooded Oriole	*Icterus cucullatus*	MIS
Hairy Woodpecker	*Picoides pubescens*	MIS
Warbling Vireo	*Vireo gilvus*	MIS
Western Wood Pewee	*Contopus sordidulus*	MIS
Arizona Gray Squirrel	*Sciurus arizonensis*	MIS

Table Legend

E = Federally listed as Endangered under Endangered Species Act (ESA)
EXNE = Federally Endangered, Experimental, Non-essential
T = Federally listed as Threatened under ESA
P = Federally Proposed for listing under the ESA
C = Federally designated as Candidate for listing
WC = Wildlife of Special Concern in Arizona (AGFD in prep. 1996)
Sen = On Regional Forester's Sensitive Species List (7/21/99)
HP = High Priority Species; "at high risk of imperilment" (Western Bat Species Regional Priority Matrix (1998)
MIS = Tonto and Coconino Management Indicator Species from the Respective Forest Plans

SC = Federal Species of Concern (former C2 species)

Birds

Janie Agyagos and Michele James

Federally Threatened, Endangered, and Candidate Species

Four federally listed as threatened or endangered birds are known to occur, or have existing or potential habitat within the Fossil Creek watershed. These are the threatened bald eagle (*Haliaeetus leucocephalus*) and Mexican spotted owl (*Strix occidentalis lucida*), and the endangered southwestern willow flycatcher (*Empidonax traillii*) and

Yuma clapper rail (*Rallus longirostris yumanensis*). Habitat (as well as one documented observation) for the yellow-billed cuckoo (*Coccyzus americanus occidentalis*), a federal candidate for listing, occurs in the watershed as well.

Bald Eagle (Haliaeetus leucocephalus)

Bald eagles are known to nest along the Verde River on the Coconino, Prescott, and Tonto National Forests. Two bald eagle breeding areas occur on the Verde River within proximity of the Fossil Creek watershed. The East Verde breeding area is located just over 1 mile downstream of the confluence of Fossil Creek on the Verde River. This pair of bald eagles has been known to nest in this location in 1984, 1985, 1987, and 1998 and are among the most successful reproducing eagles in Arizona. The Coldwater North and Coldwater South breeding areas have been used by the same pair of eagles but in different years. The Coldwater South breeding area was occupied for the first time in 1998. This breeding area, located on the Verde River between the Childs Power Plant and the confluence with Fossil Creek, has not been used since 1998 when this first attempt to nest in a new location failed and no young were produced. The Coldwater North breeding area is located one and one-half miles upstream of the Childs Power Plant and was used in 1998 and 1999. The nests failed in both these years. Other nest locations associated with the Coldwater North breeding area are located approximately six miles upstream of the Child's Power Plant. The pair attempted to nest in this area in 2000, but the nest failed.

According to the Arizona Game and Fish Department, the Coldwater eagles, even when nesting six miles upstream of Childs frequently use the reach of the Verde between Childs and the Fossil Creek confluence for foraging. Telemetry during the 1987 breeding season indicated that the male bald eagle visited Fossil Creek a number of times in April, foraging on spawning suckers and using hunting perches 2.5 miles up Fossil Creek (Hunt et al. 1992).

Wintering bald eagles are known to use the Verde River and are consistently detected during midwinter surveys from the East Verde up to the West Clear Creek confluence. Fossil Creek above its confluence with the Verde River is not included in any bald eagle midwinter survey routes, and the fishery supported by minimal flows currently at Fossil Creek provides limited foraging and roosting habitat for bald eagles. Stehr Lake provides potential foraging and roosting habitat for bald eagles although eagles are not known to use the lake and habitat may be marginal.

Wintering bald eagle use night communal roosts that are often located on slopes (Platt 1976; Hansen et al. 1980; Dargan 1991) or are protected from prevailing winds by surrounding vegetation (Sabine 1981; Steenhof 1976). Within the Fossil Creek watershed, communal bald eagle roosts may potentially occur in the over 5,500 acres of mixed conifer, ponderosa pine, and pine/oak vegetation present in the Sand Rock and Calf Pen Canyons, where suitable conditions occur (steep slopes, wind protection, open canopy, and larger trees). Grubb and Kennedy (1982) document Fossil Springs as an area where there was either historic or reported use. Due to the presence of large trees protected from wind by adjacent slopes along portions of the creek, potential roosting habitat occurs along Fossil Creek. No known bald eagle winter roost sites are known to occur in the watershed however.

Mexican Spotted Owl (Strix occidentalis lucida)

Spotted owl habitat in the watershed consists of mixed conifer and ponderosa pine-Gambel oak vegetation types. This habitat is usually characterized by high canopy closure, high stem density, multi-layered canopies within the stand, numerous snags, and downed woody material. Often, nesting and roosting habitat for the spotted owl is located on steep slopes or in canyons with rocky cliffs, where dense vegetation or crevices or caves provide cool moist microsites.

There are three known spotted owl protected activity centers (PACs) within the watershed. These PACs are at least 600 acres in size and are designated around known nest and/or roost sites of a pair or single spotted owl. The PACs in the watershed include Sandrock (No. 040103), Calf Pen (No. 040421), and Horse (No. 040444). These PACs are located primarily in mixed conifer and ponderosa pine-Gambel oak vegetation in the northeastern portion of the watershed.

Spotted owls nest in riparian gallery forests, however, no breeding spotted owls have been documented in riparian forests in recent times (USDI 1995). Surveys for the spotted owl have not been conducted in the riparian portions of the watershed. According to definitions of habitat as described in the Mexican Spotted Owl Recovery Plan (USDI 1995), the riparian area along Fossil Creek and the Verde River qualify as restricted habitat, and the lands within the Wilderness boundaries and the Botanical Area qualify as protected habitat. Currently, there is little or no suitable nesting habitat in the riparian areas within the watershed. The Fossil Springs area provides suitable habitat structure, but its extremely small size probably precludes its use by nesting owls. Riparian habitat along the rest of the 14 miles of Fossil Creek does not currently provide the density and structure needed for good nesting habitat.

Some spotted owls are known to migrate in the winter, usually to lower elevations consisting of more open woodland or scrub habitats (USDI 1995). The watershed contains over 140,000 acres of pinyon-juniper woodlands and desert scrub vegetation that may provide habitat for wintering and possibly dispersing, spotted owls.

Southwestern Willow Flycatcher (Empidonax traillii extimus)

In the Verde Valley, nesting habitat for the willow flycatcher occurs in tamarisk and mixed riparian habitats. Patch width of breeding sites in both tamarisk mixed riparian habitat types tend to be more linear, varying from 460 feet to 1,640 feet in maximum width (Sferra et al. 1995). Overstory canopies average between 50 and 55 feet tall, and patch size varies from 5 to 121 acres in mixed riparian and tamarisk (Spencer et al. 1996).

Surveys for the southwestern willow flycatcher have been conducted at several locations along Fossil Creek. In 1994, U.S. Forest Service personnel conducted surveys at Fossil Springs and along the six miles of Fossil Creek below the dam. Later, the Forest Service determined that these areas were unsuitable for nesting flycatchers. Environet consultants surveyed three additional sites in 1998; these were located 800 feet, 1.2 miles, and 2 miles downstream of Irving. The three sites were selected for surveys based on aerial inventory of habitat which indicated that these where the widest and thickest areas of riparian habitat. Surveys conducted in 1998 at these sites did not located flycatchers. Comparison of the three sites along Fossil Creek with occupied sites in the Verde Valley indicate that these sites have little to no potential for supporting nesting willow flycatchers. Riparian habitat along Fossil Creek differs from habitats typically occupied by southwestern willow flycatchers in the Verde Valley and in Arizona. The riparian vegetation is too narrow and the mid and understory vegetation layers are relatively open.

Yuma Clapper Rail (Rallus longirostris yumanensis)

The Yuma clapper rail nests and lives in freshwater marshes where moist to wet soil and dense vegetation at least 40 cm (15.7 inches) in height occurs (Todd 1986; Eddleman and Conway 1998). Flooded areas are important, but generally the rail uses areas of shallow water (<12 in) near shore.

Currently there is no nesting habitat for Yuma Clapper rails along Fossil Creek. Increased flows into Fossil Creek may provide adequate size patches of emergent vegetation suitable for nesting, however, spring flows from snow melt and spring precipitation would likely result in fluctuating water levels that could inundate Yuma clapper rail nests. While suitable habitat occurs in Stehr Lake, surveys conducted by Environet in 1998 failed to detect nesting rails.

The Verde River above and below Fossil Creek's confluence may support suitable Yuma clapper rail habitat. Recent changes in livestock management along the Verde River are allowing for riparian vegetative species to become established. This includes deciduous tree, herbaceous, emergent and aquatic species.

Western Yellow-billed Cuckoo (Coccyzus americanus occidentalis)

The future of the yellow-billed cuckoo (*Coccyzus americanus*), a neotropical migrant that breeds throughout northern Mexico, the United States, and southern Canada, is uncertain (Hughes 1999). Yellow-billed cuckoo populations have declined throughout the species' range (Hughes 1999); western populations, in particular, have decreased and suffered catastrophic range reductions in the twentieth century (Laymon and Halterman 1987; Hughes 1999; Corman and Magill 2000). Consequently, on July 25, 2001, the yellow-billed cuckoo became a Candidate Species under the Endangered Species Act (ESA). Yet, despite concern over the fate of this species, few aspects of yellow-billed cuckoo life history have been adequately studied (Hughes 1999). Probable factors believed to be contributing to population declines are the loss, fragmentation, and alteration of native riparian breeding habitat, the possible loss of wintering habitat, and pesticide use on breeding and wintering grounds (Corman and Magill 2000).

The facts that yellow-billed cuckoos were once common and now are extremely rare and that riparian habitats have been severely impacted demonstrate that there is a clear need to elucidate the interrelationships of yellow-billed cuckoo ecology and riparian habitat conservation. Indeed, after conducting surveys for yellow-billed cuckoos, Arizona Game and Fish Department concluded that: 1) The surveys should be expanded to encompass all major habitat types; 2) Additional presence/absence data was needed from areas within potentially suitable habitat that were not thoroughly surveyed; and, 3) Nest searching and monitoring should be initiated to gain a better understanding of productivity and nest site behavior (Corman and Magill 2000). The need to better understand the factors that are contributing to the decline of yellow-billed cuckoo populations within the state is reflected in the Arizona Game and Fish Department Heritage Program's selection of the yellow-billed cuckoo as a Sensitive Element in 2001 and 2002.

The yellow-billed cuckoo is a late migrant associated with large tracts of undisturbed riparian deciduous forest where willow, cottonwood, sycamore, or alder occur. Yellow-billed cuckoos in higher elevations may be found in mesquite and tamarisk. The yellow-billed cuckoo feeds almost entirely on large insects, and if food-stressed, may also feed on berries and fruit. Forest Service records indicate that a yellow-billed cuckoo was detected in the Fossil Creek riparian area by Coconino biologist Cathy Taylor. Arizona Game and Fish conducted a survey for the cuckoo at Verde Hot Springs along the Verde River however no cuckoos were detected. Yellow-billed cuckoos could potentially occur in Fossil Creek from Fossil Springs down to the Verde confluence and more surveys need to be conducted.

<u>Sensitive and Management Indicator Species (MIS)</u>

American Peregrine Falcon (Falco peregrinus anatum)

Habitat for peregrine falcon includes rock cliffs for nesting and a large foraging area. Suitable nesting sites on rock cliffs have a mean height of 200 to 300 feet. Peregrines prey mainly on birds found in wetlands and riparian areas within a 10 to 20 mile radius from the nest site. Prey items include mainly birds, especially passerines, doves, and small raptor, as well as bats, and other mammals.

Survey efforts by the Arizona Game and Fish Department in the early 1990's resulted in the identification of two peregrine eyries within the vicinity of Fossil Creek. The Nash Point eyrie occurs 1.5 miles east of Fossil Springs and the Calf Pen eyrie occurs 4.5 miles northeast of Fossil Springs. Another eyrie occurs approximately two miles downstream from the Fossil/Verde confluence. Both eyries within the watershed were monitored by Arizona Game and Fish biologists from 1989 to 1995.

Besides the occupied habitat, additional suitable nesting habitat occurs in the watershed where cliff faces greater than 200 feet in elevation occur. Arizona Game and Fish conducted habitat suitability surveys along the Fossil Creek road; biologists did not consider the cliffs along Fossil Creek from one mile below Fossil Springs to Stehr Lake as suitable nesting habitat. Surveys were not conducted below Stehr Lake yet cliffs in excess of 200 feet do occur there and along other sections of Fossil Creek. Since the peregrine was delisted from the Endangered Species Act, peregrine nests are being discovered in habitat previously thought to be less than suitable. Therefore, it is now believed that peregrine falcons could occur throughout most of Fossil Creek. Environet biologists identified and mapped 7,230 acres of potential nesting habitat along Fossil Creek. Additionally, peregrine falcons may forage all along Fossil Creek, the Verde River, and at Stehr Lake where prey species such as swallows, swifts, and waterfowl may occur.

Common Black Hawk (Buteogallus anthracinus)

The common black hawk can be found in low elevation riparian areas. The black hawk is dependent upon a mature, relatively undisturbed habitat supported by a permanent flowing stream. Groves of tall trees must be present along the stream course for nesting. Black hawks are still hunters, hunting from tree and cliff perches although they will also wade into water and chase after prey including crayfish, amphibians, reptiles, and fish. Streams of low to moderate gradient and less than one foot deep with scattered boulders are ideal for foraging.

The common black hawk has been observed in all reaches of Fossil Creek except the lower reach below Irving. There have been no observations of black hawks at Stehr Lake. Suitable nesting habitat currently occurs from Fossil Springs downstream to the Irving power plant and where significant springs provide for tall trees and foraging habitat.

Bell's Vireo (Vireo bellii)

Bell's vireos occupy dense riparian thickets as well as mesquite and oak thickets near water. Arizona Partner's In Flight list the Bell's vireo as an associate species to the southwestern willow flycatcher and Lucy's warbler. According to Forest Service data, Bell's vireos have been detected at a variety of locations including Fossil Springs, Fossil Spring Botanical Area, Fossil Creek, Stehr Lake, aqueduct spring, and Fossil Creek uplands. Bell's vireos may occur in the watershed wherever mesquite thickets occur near water and along riparian areas, including small springs.

Yellow-breasted Chat (Icteria virens)

The yellow-breasted chat inhabits riparian areas with small trees and dense shrubs. Adults eat an equal portion of berries and insects gleaned from shrubs; young chats eat only insects. The yellow-breasted chat has been observed at Fossil Springs, along Fossil Creek and at Stehr Lake.

Cinnamon Teal (Anas cyanoptera)

The cinnamon teal inhabits marshes, ponds, slow streams, alkaline wetlands in arid areas and shallow lake margins with emergent vegetation. Nests are built on the ground, usually in a marsh or adjacent meadow. Dense, high vegetation is important for nest concealment. The teal's diet is based on the seeds of aquatic vegetation, insects and mollusks. It forages in shallow water along shorelines. Although this species is listed as a Management Indicator Species for the Riparian and Open Water Management Area in the Coconino National Forest Plan, this species has not been sighted in the Fossil Creek area. Stehr Lake likely provides the best habitat.

Lucy's Warbler (Vermivora luciae)

This warbler can be found in mesquite forests of the desert southwest and in mountain foothills. It is particularly fond of willow and cottonwood groves, and breeds in riparian brush and woodlands. Lucy's warblers are cavity nesters, making nests in old woodpecker holes, under loose bark, in natural cavities, in abandoned Verdin (*Auriparus flaviceps*) nests and occasionally in holes located in stream banks. Nests are located 2 to 15 feet above the ground. Lucy's Warblers are insectivores, pursuing their prey by gleaning from foliage or by hawking, sallying from their perch to catch insects in the air. Forest Service data indicates that Lucy's warblers have been sighted at Fossil Springs and in the reach above Irving.

Lincoln's Sparrow (Melospize lincolnii)

Lincoln's sparrow is found in wet areas such as bogs, marshes and wet meadows, in dense willow or alder thickets, along forest edges, in open forests with well-developed under-stories and in clearings. Nests are built on the ground in a tussock of grass or sedge, concealed by vegetation and sometimes just above water. These birds glean their food from the ground, with adults feeding on insects, spiders, grains and seeds, and juveniles feeding only on insects. Although the Fossil Creek area provides some habitat for the Lincoln's sparrow, according to Forest Service data, none have been observed in the Fossil Creek area.

Summer Tanager (Pirangra rubra)

The summer tanager inhabits riparian woodlands, stands of cottonwood and willow and park-like areas. Nests are built on horizontal tree limbs 10 to 35 feet above the ground. Summer tanagers eat insects, spiders and fruit. The summer tanager has been observed at the Fossil Springs, along Fossil Creek, at Childs and at Stehr Lake.

Hooded Oriole (Icterus cucullatus)

The hooded oriole is found in riparian woodlands, particularly mesquite, cottonwood, sycamore and walnut. Nests are also built in willow, ash, or Spanish bayonet, where nests are built from the fibers of the plant. Insects, fruit and nectar make up the diet. The hooded oriole has been observed at Fossil Springs, along Fossil Creek, at Childs and at Stehr Lake

Hairy Woodpecker (Picoides pubescens)

This woodpecker inhabits deciduous and coniferous forests. Nests are dug in live or dead trees 5 to 40 feet above the ground. Trees with dead centers are favored. Sometimes an additional cavity for roosting is constructed. The hairy woodpecker eats insects primarily, but also feeds on sap from sapsucker holes. According to Forest Service data, the hairy woodpecker has only been sighted at the Fossil Springs.

Warbling Vireo (Vireo gilvus)

The warbling vireo inhabits open deciduous and mixed woodlands, riparian forests, and thickets. Nests are built in the horizontal fork of slender tree branches, well away from the trunk, often in aspen or poplar. In the west, warbling vireos nest in shrubs or low trees, within 12 feet of the ground. They feed chiefly on insects, along with spiders and berries. The warbling vireo has only been sighted at Fossil Springs.

Western Wood Pewee (Contopus sordidulus)

The western wood pewee is found in a number of habitat types, including open, mature pine forest; pine-oak-aspen woodlands; wooded canyons; orchards; towns and cultivated valleys. It appears to prefer nesting in deciduous trees, but conifers are used on occasion. Nests are built in living or dead trees, on horizontal limbs far from the tree's trunk or in limb forks. They are typically situated between 15 and 40 feet above the ground. They feed on insects, foraging in the air among the mid-foliage portion of trees. The western wood pewee has been observed at Fossil Springs and along Fossil Creek.

<u>Summary of Special Status Birds</u>

All 17 species of special status birds (4 listed, 4 sensitive, and 9 MIS) are riparian dependent either for all or a portion of their life cycle. Table 17 displays each species requirement for riparian habitat.

Table 17: Special status bird use of riparian habitat.

Species	**Nesting**	**Foraging**	**Dispersal/ Migration Corridor**	**Wintering**
Bald Eagle	X	X	X	X
Mexican Spotted Owl	X*		X	
Southwestern Willow Flycatcher	X	X	X	
Yuma Clapper Rail	X	X	X	X
American Peregrine Falcon		X		
Common Black Hawk	X	X	X	
Western Yellow-billed Cuckoo	X	X	X	
Bell's Vireo	X	X	X	
Yellow-breasted Chat	X	X	X	
Cinnamon Teal	X	X	X	X
Lincoln's Sparrow	X	X	X	
Lucy's Warbler	X	X	X	
Summer Tanager	X	X	X	
Hooded Oriole	X	X	X	
Hairy Woodpecker	X	X	X	X
Warbling Vireo	X	X	X	
Western Wood Pewee	X	X	X	

* historically

Resident and Neotropical Migratory Birds Occurring in the Fossil Creek Area

Many of the birds in the Fossil Creek area are neotropical migrants, spending only a portion of each year (spring and summer) in this area. These birds travel each year from their wintering grounds in Mexico, Central and South America, and the Caribbean to North America to breed during the spring and summer months. Precipitous declines in neotropical migratory bird populations have occurred over the last twenty years and are caused mainly by habitat loss and modification in the wintering grounds, breeding grounds, and along migrational routes. Due to the abundance of quality riparian habitat in the Fossil Creek area, neotropical migrants not only use the area for nesting but also as a corridor for migration.

See Appendix B for a complete list of bird species observed through 2003 within the watershed according to Forest Service records.

Federally Listed and Candidate Species

The ultimate goal for federally listed species is recovery. The restoration of Fossil Creek may increase habitat quality and quantity for some of these bird species, thereby assisting to some degree in recovery. Return of full flows may allow additional riparian habitat to develop in the long-term on suitable streamside substrates (USDA Forest Service 2003b). This may result in increased width of the riparian area along some parts of Fossil Creek and thus, suitable nesting habitat for the southwestern willow flycatcher may develop over time. While habitat for the yellow-billed cuckoo is currently present along Fossil Creek, restoration of full flows may increase the health of the willow and cottonwood trees currently present and allow for the continued health and presence of these large trees that are used for nesting by this species. Roosting and foraging habitat for the bald eagle may improve along Fossil Creek with the return of full flows. A wider riparian area may result in the use of the Fossil Creek corridor by dispersing Mexican spotted owls.

Recreational activities may result in visual and aural disturbance to listed and candidate bird species that are present in the area. Frequent, long-term, and/or high intensity disturbance can result in abandonment of an area by adult birds, decreased reproduction, increased predation of young and eggs, and decreased foraging success by adults. The yellow-billed cuckoo, for instance, is sensitive to disturbance and avoidance of intense and repeated human disturbance in nesting areas from 20 May through 1 September is recommended (Latta et al. 1999). Recreational activities in the riparian area can cause stream bank compaction, loss of vegetation, and overall loss of habitat quality for listed and candidate bird species. Management of recreational use in the Fossil Creek Watershed, particularly in and adjacent to the riparian area, should be carefully considered. The location of campsites, creek side trails, and access trails should consider the maintenance of habitat for listed species. Because these are listed or candidate species, the protection of individuals and nest sites are required; seasonal restrictions of recreational use in specific areas may need to be implemented.

Sensitive and MIS Species

Many of these birds are neotropical migrants, spending only a portion of each year (spring and summer) at Fossil Creek. Precipitous declines in neotropical migratory bird populations have occurred over the last twenty years and are caused by habitat loss and modification, both on their wintering and breeding grounds. Due to the abundance of quality riparian habitat in the Fossil Creek area, neotropical migrants use the area for nesting as well as a corridor for stop-over during migration. Restoration of full flows may allow for increased habitat quality and quantity for these species.

Conserving and improving the health of the Fossil Creek riparian area and maintaining water quality are the primary goals for these species. As discussed above, recreational use of the area, particularly the sensitive riparian areas can result in loss of habitat quality for sensitive species. The presence of appropriate restroom facilities can help ensure that the water quality of Fossil Creek is maintained. Careful attention should also be paid to the health of ranid frogs in this area. Frogs are some of the best indicators of habitat health, thus carefully watching for fog die-offs, and quickly identifying the cause is recommended. Non-native species such as sport fish, bull frogs and crayfish, and the invasion of exotic plant species have contributed to ranid frog declines (Sredl 1997), as well as the spread of the Chytrid fungus. The removal of non-native fish is expected to result in beneficial effects for frogs in Fossil Creek. Die-offs of ranid frogs, particularly the lowland leopard frog, could have serious effects on the common black hawk, as these amphibians make up a large portion of the black hawks diet (Latta et al. 1999).

Some of these birds are sensitive to recreational disturbance. Human visitation should be minimized to protect the common black hawk, for instance, during the breeding season (approximately March through mid October) (Latta et al. 1999). Recreational activities in the riparian area should be managed carefully to allow the protection of habitat for these sensitive species. Protection of trees used by cavity nesting birds such as the Lucy's warbler is recommended. This may require restrictions on opportunistic fuel wood harvest near recreational camping areas if camp fires are permitted.

Inventory and Monitoring

Little is known about the use of the Fossil Creek watershed by these listed and sensitive bird species. For instance, systematic inventory of the riparian habitat for the yellow-billed cuckoo and common black hawk has not occurred to date although potential habitat is abundant. Surveys for the yellow-billed cuckoo and black hawk are planned in conjunction with the decommissioning activities, starting in 2005. The extent of these surveys is limited to the 4.5 miles upstream of Irving (pers. comm. Matt Johnson, USGS), and thus do not include other potential habitat within the middle and lower reaches of Fossil Creek. We recommend two consecutive years of inventory of all potentially suitable habitat for listed and candidate bird species (using accepted protocols) within the upper, middle, and lower reaches of Fossil Creek be completed by 2010.

While the opportunistic observations of birds in Fossil Creek to date are valuable, habitat is present for many more birds than have been observed thus far. A complete inventory of bird species in the riparian area would provide valuable information about the state of the bird species and communities and would assist in determining changes in the quality or quantity of habitat over time, thus assisting in determining appropriate management actions. In light of this, we recommend conducting baseline inventory for all species within the riparian habitat along all reaches of Fossil Creek. Baseline inventory should consist of point count surveys for breeding birds (three visits between 15 May and 30 June) as well as incidental surveys during the breeding period, spring migration (1 March through 30 April), and fall migration (15 August through 15 October) and wintering period (1 November through 30 February) consisting of a total of nine visits. We also recommend surveys for nocturnal species within the riparian habitat. Surveys for nocturnal birds (i.e., owls) would be conducted using taped broadcasts in all habitats that may be occupied by owls or where historical sightings have been noted. Nocturnal surveys could be coordinated with the other surveys described above. We suggest that the baseline inventory could be prioritized by reach with consideration of the quality of the habitat and the potential for human impacts to habitat.

After inventory for listed and candidate species, and inventory for all species has been completed in a given reach, we recommend designing a monitoring program and conducing basic monitoring within a reach or reaches. Optimally, the monitoring would occur every two years. In general, birds are considered a valuable monitoring tool because their dynamics closely parallel those of the ecosystem, they are sensitive enough to provide an early warning of change, they provide continuous assessment over a wide range of stresses and have dynamics that can be attributed to either natural cycles or anthropogenic stressors (Johnson et al. 2003). Because riparian habitat may change over the next five to 10 years with the return of full flows to Fossil Creek, bird monitoring would document any changes in the bird community that may occur after the baseline inventory is completed. In light of keeping costs for such monitoring to a minimum, the monitoring program could include sub-sampling randomly selected points or habitats within a given reach or throughout the Fossil Creek riparian habitat.

The steps involved in designing a monitoring program should include the following key components, following the suggestions of Noon et al. (1999):

1.) Identification of stressors relating to management goals.
2.) Development of a conceptual model linking stressors to ecological responses.
3.) Identification of avian indicators responsive to environmental stressors.
4.) Estimation of the status and trend of avian indicators/Establishment of sample design.
5.) Definition of response criteria/calculation of benchmark conditions.
6.) Linkage of monitoring results to decision-making.

Funding to complete inventory and monitoring of Fossil Creek is currently limited and grants should be actively pursued to fund the surveys in whole or part. We recommend pursuing funding opportunities such as the National Fish and Wildlife Foundation, Heritage Fund, and the Environmental Protection Agency. In addition, creative solutions should be considered. For minimal cost, volunteers from Northern Arizona Audubon, for instance, could conduct baseline monitoring during the migration and wintering periods. Surveyors would need to utilize a standard protocol, be committed and organized, and keep complete and accurate records. Oversight by a qualified biologist would be required. We recommend against the use of volunteers for the baseline inventory during the breeding season because detecting breeding birds takes special abilities and training as 80% of breeding birds are detected by ear alone. We believe that baseline inventory could be conducted at a minimal cost with the hiring of a project leader and one field technician.

Indicators

The best indication of the restoration of Fossil Creek and the appropriate management of recreational use of the area will be the health of the riparian ecosystem, water quality, and the presence or absence of listed and sensitive species where suitable habitat exists. A comprehensive comparison of the presence or absence of these species prior to and after the return of full flows will not be possible. However habitat changes over time (5-10 years) can indicate the overall health and changes in quantity of specific habitat. In some cases, this can be linked to use by a particular species. An overriding indicator will be the increased knowledge gained of the use of the Fossil Creek area by listed and sensitive species, as well as breeding, migrating, and winter species.

Mammals

Janie Agyagos and Michele James

Game mammals in the Fossil Creek area include elk, mule deer, white-tailed deer, bear, mountain lion, bobcat, gray fox, coyote, javelina, cottontail and jackrabbits, squirrels, and raccoons. Elk are primarily found in mixed conifer and pondersa pine woodlands during the spring, summer and fall months but move into pinyon-juniper woodlands during the winter, especially when deep snows preclude access to forage in the higher country. Deer, mountain lion, bobcat, coyote, fox, cottontails and jackrabbits occur throughout all biotic communities within the Fossil planning area. Javelina occur in desertscrub, grassland, riparian, and chaparral and pinyon/juniper slopes with abundant prickly pear cacti. Raccoons occur primarily within riparian and other vegetative zones within close proximity to riparian areas.

Non-game mammal species include chipmunks, mice, rats, woodrats, skunks, ring-tailed cats, and numerous species of bats. Spotted and striped skunks occur primarily within riparian and other vegetative zones within close proximity to riparian areas. Cliff chipmunks, white-footed mouse, and white-throated woodrat are a few small mammal species that occur within the chaparral and pinyon-juniper habitats. Rock squirrel, cliff chipmunk, western harvest mouse, and brush mouse are other small mammals that likely occur in the Fossil Creek watershed.

Approximately 22 species of bats (including special status species) may occur in the Fossil Creek area (Table 18). Few surveys have been conducted for bats in the Fossil Creek area but several occupied bat roosts are known to occur in cliff dwellings and an abandoned shack. Other roosts likely occur in natural structures such as underneath loose bark on snags, in tree and snag cavities, under rocks, in the cracks and crevices of cliffs, and in man-made structures such as bridges, buildings, and flume tunnels. All of the bat species occurring or potentially occurring in the area are insectivorous. Water sources such as earthen stock tanks, springs, seeps, and streams are important for bat foraging due to the abundance of insects found flying above the water.

*Table 18. Potential bat species and their habitat requirements**.*

Common Name	Scientific Name	Roost Requirements					Habitat						
		S	**R**	**C**	**T**	**F**	**MC**	**PP**	**PJ**	**C**	**DS**	**G**	**R**
California leaf-nosed bat	*Macrotus californicus*			X					X		X		
Yuma myotis	*Myotis yumanensis*	X	X	X				X	X		X	X	X
Cave myotis	*Myotis velifer*	X		X							X		
Occult little brown bat	*Myotis lucifugus occultus*	X		X	X			X					
Long-eared myotis	*Myotis evotis*	X	X	X	X		X	X	X	X			
Southwestern myotis	*Myotis auriculus*							X	X	X	X		
Fringed myotis	*Myotis thysanodes*	X		X	X		X	X	X	X	X	X	
Long legged myotis	*Myotis volans*	X	X	X				X	X		X		
California myotis	*Myotis californicus*			X				X			X		
Western small-footed myotis	*Myotis ciliolabrum*		X	X				X	X	X			X
Pallid Bat	*Antrozous pallidus*							X	X				
Silver-haired bat	*Lasionycteris noctivagans*						X	X	X				
Western pipistrelle	*Pipistrellus Hesperus*			X			X	X	X		X		X
Big brown bat	*Eptesicus fuscus*			X			X	X	X	X	X	X	X
Red bat	*Lasiurus borealis*					X							X
Hoary Bat	*Lasiurus cinereus*						X	X	X				
Spotted Bat	*Euderma maculatum*		X				X	X	X	X	X	X	X
Allen's big-eared bat	*Idionycteris phyllotis*		X	X	X		X	X	X				X
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*			X			X	X	X		X		
Mexican free-tailed bat	*Tadarida brasiliensis*			X				X	X	X	X	X	
Big free-tailed bat	*Nyctinomops macrotis*			X							X		X
Western mastiff bat	*Eumops perotis californicus*		X								X		

Legend for Table

S = Structures such as buildings, barns, bridges
R = Cracks and crevices in cliffs, and under rocks
C = Caves, cliff dwellings, mines, tunnels
T = Hollow trees, snags, underneath loose tree bark
F = Among foliage of trees and leafy shrubs
MC = Mixed Conifer
PP = Ponderosa Pine
PJ = Pinyon Juniper
C = Chaparral
DS = Desert Scrub
G = Grassland
R = Riparian

* Table information obtained from AGFD Heritage Data Management System; Tuttle and Taylor 1994; Hoffmeister 1986; Morrell et al. 1999; Chung-MacCoubrey 1995; and, AGFD 1992.

Southwestern River Otter (Lutra canadensis sonora)

The Southwestern river otter requires permanent flowing water or ponds, overhanging bank vegetation, and haul-out sites suitable for leaving and entering water. The species requires high quality water with low sediment loads with minimum estimated water flows of 10 cubic feet per second. Forage items include fish, amphibians, turtles, crayfish, and other aquatic animals. Otters do not build their own den but may utilize or enlarge cavities in rock piles, dense vegetation, logjams, natural cavities, and abandoned dens of other animals especially beaver. Dens may be up to one half mile from water. Otters may move considerable distances over land when mating.

The Southwestern river otter is historic to the Verde River, Wet Beaver Creek, Oak Creek, and other major tributaries in the Verde Valley. Evidence suggests that a few populations persisted at least into the 1960's and likely to the present. In 1981 and 1982, Arizona Game and Fish Department introduced a Louisiana subspecies (*L. c. lataxina*) into Fossil Creek and the Verde River near the Fossil Creek and East Verde confluences. This introduced species is successfully reproducing and may eventually cause genetic swamping of the native form, if any still exist. U.S. Forest Service and Arizona Game and Fish Department personnel have conducted wildlife surveys along the Verde River from Beasley to Sheep Bridge and have noted otter sightings and scat abundance. Bill Burger with Arizona Game and Fish (pers. comm. to Janie Agyagos, USFS 3/04/02) noted abundant otter sign between Child's and Sheep bridge each summer from 1999 to 2001. Burger also conducted a survey from Beasley Flats to Childs in 2001 and noted otter sign in that reach as well. According to Mike Ross, Tonto National Forest biologist, 18 otters were observed between Childs and Sheep Bridge in 1999, one otter and much scat in 2000, no otters but much scat in 2001, and no otters and little scat in 2002 (personal communication to Janie Agyagos, USFS, 03/06/02).

Otters have not been detected in Fossil Creek, which may be due to unnaturally reduced flows. However, once the decommissioning process occurs, the restoration of natural flows should allow for re-occupancy. Otters will likely initially extend their range up into the lower portion of Fossil Creek but over time it is possible that otters may come to occupy all of Fossil Creek.

Western Red Bat (Lasiurus blossevillii)

In Arizona, the western red bat is thought to be a summer resident only. It occurs statewide, except in desert areas, but primarily along riparian corridors among oaks, sycamores, and cottonwoods at elevations between 2,400 and 7,200 feet. Red bats typically roost in dense clumps of foliage in riparian or other wooded areas. Roost sites are shaded above and tend to be open below, permitting the bats to drop into flight. Red bats feed mainly on flying insects. The chief threats to the red bat in Arizona are its apparently low numbers and the loss of riparian and other broad-leafed deciduous forests and woodlands.

Habitat for the red bat occurs at Fossil Springs, along Fossil Creek and the Verde River, upland springs that support deciduous riparian tree species, and perhaps at Stehr Lake, although the mature deciduous riparian trees at Stehr Lake are dead or dying.

California Leaf-nosed Bat (Macrotus californicus)

California leaf-nosed bats range through southern California, southern Nevada, southwestern Arizona, and southward to the southern tip of Baja California (Mexico), northern Sinaloa (Mexico), and southwestern Chihuahua (Mexico). They tend to live in the same area year after year, and do not migrate.

The California leaf-nosed bat lives predominantly in Sonoran and Mohave Desert scrub habitats, but is occasionally found in the Chihuahuan and Great Basin deserts. During the day, this species roosts primarily in mines and caves. At night it may rest in open buildings, cellars, bridges, porches, and mines that offer overhead protection but which are open for adequate flight approach. The California leaf-nosed bat is a year-round resident in desert scrub habitats south of the Mogollon Rim in Arizona. Within the 5^{th} code watershed the Forest Service estimates 15,811 acres of desert scrub vegetation.

Spotted Bat (Euderma maculatum)

Historic records suggest that the spotted bat was widely distributed but quite rare over its range, although it may have been locally abundant at certain sites. The historic range of the spotted bat includes Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Wyoming, Texas, Canada and Mexico.

Roost site characteristics are poorly known for this species, but limited observations suggest that spotted bats roost singly in crevices, with rocky cliffs and surface water characteristic of localities where they occur. The diet of the spotted bat consists of moths, June bugs, and grasshoppers as well as other insects.

As of 1986, very few specimens were known from Arizona. Sites varied from southeastern, south central, to northeastern parts of the state. *Euderma maculatum* is rarely and unpredictably encountered in various habitats in scattered localities throughout Arizona, but especially in the extreme northwestern corner. It has been found from low desert areas in southwestern Arizona to high desert and riparian habitat in the northwestern part of the state. It has also been found in conifer forests in northern Arizona and other western states.

Since this bat occurs in a variety of vegetation types where suitable rocky cliffs occur, the majority of the watershed, especially, Calf Pen and Sand Rock Canyons, Fossil Creek between the Fossil Springs and Irving Power Plant, and along the Verde, would provide suitable roosting conditions for this bat.

Allen's Big-eared Bat (Idionycteris phyllotis)

Allen's big-eared bats are found in the mountainous regions of the southwestern United States through central Mexico, where they primarily dwell in caves and abandoned mine shafts within mountainous pine, pine/oak, and pinyon-juniper forests. Its historic range includes Arizona, California, Colorado, New Mexico, Nevada, Utah and Mexico (Federal Register, 1994). Records of capture exist across most of Arizona, with most records from the southern Colorado Plateau, the Mogollon Rim and adjacent mountain ranges within ponderosa pine, pinyon-juniper, Mexican woodland and riparian areas of sycamores, cottonwoods and willows. Allen's big eared bats generally occur at elevations ranging from 2,600 - 9,800 feet, but most specimens are at altitudes between 3,500 - 7,500 feet. Nearly all capture sites have been in the vicinity of rocks, such as cliffs or large boulders, which are their most probable roosting sites. The availability of water holes is a significant factor in habitat selection due to their high rate of evaporative water loss.

Although there are many thousands of acres of ponderosa pine, pine/oak, pinyon-juniper, and riparian woodlands in the watershed, the sporadic water availability may limit roosting activity. There are 12 springs and 22 man-made earthen tanks in the area within ponderosa, pine/oak, and pinyon-juniper vegetation types but many of these springs and tanks dry up at different times during the year. Riparian areas associated with perennial water in Fossil Creek, coupled with the abundant cliffs and the appropriate vegetation, makes for the most suitable habitat in the Fossil Creek area.

Townsend's Big-eared Bat (Corynorhinus townsendii)

In Arizona, this species occurs throughout the state, although it is only infrequently found in the Desert Mountains. During the winter, it is found mostly south of the Mogollon Plateau and northwest of Mohave County. The distribution of this bat tends to be geomorphically determined, and is strongly correlated with the availability of caves or cave-like roosting habitat e.g., old mines. Population concentrations occur in areas with substantial surface exposures of cavity forming rock, and in old mining districts. *Plecotus townsendii* has been found from 1,200 to 5,600 feet. Most records; however, seem to come from above 3,000 feet.

Townsend's big-eared bats hang from open ceilings of mines and caves during the day. They do not use cracks or crevices, and may use open abandoned buildings as a night roost. In Arizona, they hibernate during the winter in cold caves, lava tubes, and mines mostly in uplands and mountains from the vicinity of the Grand Canyon to the southeastern part of the state, south of the Mogollon Rim. The presence of suitable shelters seems to be one of the important limiting factors for this species. Townsend's big-eared bats may occur throughout the watershed where suitable roost substrate such as caves, cliff dwellings, and flume tunnels, occurs. Townsend's big-eared bats have been detected along the Verde River between West Clear and Fossil Creeks (Sullivan and Richardson 1993).

Arizona Gray Squirrel (Sciurus arizonensis)

The Arizona gray squirrel inhabits deciduous and mixed forests, canyon bottoms and riparian areas of mountain ranges. It is also found in stands of ash, mulberry, walnut, oak, sycamore and pine. Arizona gray squirrels are chiefly arboreal. Nests are made of leaves and, in winter, are sometimes occupied by more than one adult. This species feeds largely on walnuts. It also eats acorns, fungi, juniper berries and the seeds of pine and Douglas fir. The Arizona gray squirrel utilizes mature riparian trees for nest sites. Nesting gray squirrels have been reported at the springs at Fossil Creek (Burbridge and Story 1974).

Restoration Goals

The return of full flows to Fossil Creek is expected to increase the likelihood of occupancy of the Creek by the introduced subspecies (*Lutra Canadensis lataxina*) of river otters. The amount of time it will take after return of full flows for the river otter to move from the currently occupied Verde River into the lower reaches of Fossil Creek is unknown. The Forest Service indicates that it is very likely that river otters may eventually move into the middle and upper portions of Fossil Creek. While the lower reaches of Fossil Creek are remote and less accessible to recreationists, the middle portion is easily accessible and the upper portion (from Irving to the diversion dam) is accessible via a relatively short hike. Recreational use in the more accessible areas is expected to be much higher than in the lower portion of Fossil Creek and may result in disturbance to river otters and impacts to habitat caused by trampling of vegetation and bank compaction. Recreational use in this area will need to be considered carefully and the future occupation of the middle and upper portions of Fossil Creek by river otters must be taken into consideration. In particular, creek side trails and camping, as well as the presence of social trails and the number of access routes into the area should all be carefully considered and limited to an amount appropriate for the species.

In general, bat species and the Arizona gray squirrel will likely benefit from the return of full flows. The western red bat and gray squirrel, for instance, roost and nest in deciduous riparian trees and, with the return of full flows to Fossil Creek, additional riparian habitat will develop in the long-term on suitable streamside substrates (USDA Forest Service 2003b). In the short term, the saturation tolerance of some existing vegetation may be exceeded, and that vegetation would die (FERC 2004a). Because Stehr Lake will eventually dry up after return of full flows, this riparian habitat will not provide roosting or foraging habitat for bats. APS has agreed to install bat grates at the mouths of the flume tunnels as part of the deconstruction process; this will allow bats to use the tunnels for roosts while rendering the tunnels inaccessible to the public (FERC 2004b).

Recreational use in the riparian areas of Fossil Creek are a concern for bats and for the squirrel because this may cause visual and aural disturbance, and may directly impact habitat for species such as the western red bat and gray squirrel that roost and nest in riparian trees (USDA Forest Service 2003a). The Forest Service indicates that excessive smoke from campfires can affect the insect population in the immediate area, thus affecting the prey base for sensitive bat species. Management of recreation use along Fossil Creek must be considered carefully given the importance of the riparian area to sensitive bat species. As with the river otter, creek side trails and camping, the presence of social trails, and the number of access routes into Fossil Creek should be carefully considered and limited to an amount appropriate for these species.

Monitoring

Monitoring for river otters and sign such as that conducted in recent years by the Arizona Game and Fish Department and the Tonto National Forest along the Verde River should continue. Such monitoring should occur yearly if possible and should be extended into the lower reaches of Fossil Creek through at least 2010. Long-term monitoring of Fossil Creek should continue to take place in the lower reaches and be extended into the middle and upper reaches of Fossil Creek dependent upon on-going monitoring results.

Monitoring for sensitive bat species including the western red bat, California leaf-nosed bat, spotted bat, Allen’s big-eared bat, and Townsend’s big-eared bat should take place within the Fossil Creek watershed in the near future. While habitat for these species is present in the watershed, their presence is currently unknown. Such monitoring would determine if and when they are present and also determine if other bat species inhabit the area. Such monitoring should consist of, at a minimum, use of the Anabat II to record bat sonar, identify species present, and identify roost sites, if possible.

Given that the Arizona grey squirrel is a Forest Service Management Indicator Species, monitoring for the presence of this species within the riparian area of Fossil Creek is recommended. Determining if they are present, and if so, where and to what extent, will allow the Forest Service to manage for the species and its habitat more effectively.

Indicators

The presence of river otters in Fossil Creek may be a positive indication of the size of the fish population, as well as the water quality of the creek and the quality of riparian habitat. Given the native fish restoration efforts of late 2004, it may take some time for the natives to increase to the point that there is enough of a prey base to sustain otters. It is unclear when this may occur, however it is well known that the otters do well on main stem rivers such as the Verde and Oak Creek, and at the Bubbling Ponds hatchery, where fish are abundant.

Assuming that the prey base is adequate, if river otters consistently occupy the middle and upper reaches of Fossil Creek where recreational use is expected to have the most impact on the species, this may be an indication that recreational use is at an appropriate level for the species. Conversely, if river otter do not consistently occupy the middle and upper reaches of Fossil Creek despite the presence of suitable habitat, this may be an indication of recreational use at a level that is incompatible with the habitat needs of this species. Utlitmately, the determination of the suitability of Fossil Creek will be made by the river otters.

Roosting and hibernating bat species are extremely sensitive to disturbance. Their presence and health are indicative of the both the quality of habitat as well as the level of disturbance that is taking place.

Amphibians and Reptiles

Shaula Hedwall, Janie Agyagos, and Michele James

Amphibian and reptiles in the Fossil Creek area include several species of toads, frogs, lizards, and snakes. Amphibians include canyon tree frogs and lowland leopard frogs. Numerous species of lizards occur in the area; collared, fence, earless, side-blotched, and tree. Sonoran mud turtles are present in Fossil Creek (pers. comm. Cecilia Overby to Michele James). Snake species that occur in the area include: various garter snakes such as the black-necked and wandering; whip snakes; king snakes; gopher (bull) snake; and rattlesnakes such as the black-tailed, Arizona black, and Western diamondback. The species discussed below in more detail include only those special status amphibians and reptiles.

Special Status Reptiles and Amphibians

Lowland Leopard Frog (*Rana yavapaiensis*)

The lowland leopard frog was originally described by Platz and Frost (1984). The lowland is a relatively small (maximum length about 8.6 centimeters) tan, gray-brown, or light gray-green to green above, and yellow below, leopard frog (Stebbins 2003). The lowland leopard frog is distinguished from other Arizona leopard frogs by dorsolateral folds that are broken and inset towards the rear, a dark brown and tight reticulate pattern on the rear of the thigh, and usually no spots on the snout (Stebbins 2003). The historical range of the frog probably included Arizona, southeast California, southwest New Mexico, and northern Sonora and northwest Chihuahua, Mexico. The lowland leopard frog occupies permanent water in rivers, streams, springs, and persistent livestock tanks up to 4,800 feet elevation, but is more commonly found below 3,300 feet elevation. Leopard frogs are seldom found in association with predacious non-native fish species, bullfrogs or crayfish.

A breeding population of lowland leopard frogs is known to inhabit Fossil Creek, from the springs down to the Fossil Springs Diversion Dam. Some parties involved in the Fossil Creek Hydropower Decommissioning Project have expressed concern about the effects of the proposed action, specifically the removal of the Fossil Springs Diversion Dam, on the lowland leopard frog.

Nearly every ranid frog in Arizona, including the lowland leopard frog, has declined over the past two or three decades (Sredl et al. 1997). Although lowland leopard frogs seem to be the most stable ranid frog in Arizona, they have been extirpated from the lower Gila and Colorado Rivers of Arizona and adjacent California (Jennings and Hayes 1994) and may be extirpated from New Mexico (Degenhard et al. 1996). The lack of lowland leopard frog observations during 1993 surveys of large and important locations on the Verde River and Oak Creek raised concern for the viability of lowland leopard frog populations on the Coconino National Forest (Sredl et al. 1995a).

Lowland leopard frogs have been found in a number of locations on the Tonto National Forest, indicating good distribution throughout the Forest (Sredl et al. 1995b). However, on the Coconino National Forest, lowland leopard frogs have been documented in only four areas, one of which is Fossil Creek. The lowland leopard frog population above the Fossil Springs Diversion Dam constitutes over two-thirds of the total number of lowland leopard frogs on the Coconino National Forest. While habitat in varying degrees of suitability occurs below the Fossil Springs Diversion Dam, breeding populations of adult leopard frogs are not detected below the dam.

Arizona Toad (*Bufo microscaphus microscaphus*)

The Arizona toad occurs in rocky streams, canyons, and floodplains with dense riparian vegetation in elevations between 2,000 and 6,000 feet. They breed in gently flowing waters generally with well-developed riparian vegetation and feed on insects and snails. Sullivan (1991) reported Arizona toads from the Verde River just northwest of Child's Power Plant. Sullivan and Richardson (1993) reported that Arizona toads could potentially occur along the Verde River from West Clear Creek to the East Verde confluences. Although no surveys have been conducted, Fossil Creek offers suitable habitat for the Arizona toad.

Narrow-headed Garter Snake (*Thamnophis rufipunctatus*)

The narrow-headed garter snake is the most aquatic of the garter snakes, seldom found far from quiet, rocky pools in large streams and rivers. It is primarily a Mexican species, but is found in permanent drainages of the Mogollon Rim and White Mountains of Arizona. Food items include fish (native species preferred), frogs, tadpoles, and salamanders. Although there have no observations of the narrow-headed garter snake in Fossil Creek, suitable habitat currently exists throughout much of the Fossil Creek drainage (pers. comm. Erika Nowak, herpetologist, USGS; Andrew Holycross, herpetologist, ASU). The narrow-headed garter snake may potentially occur in the Verde River from West Clear Creek to Fossil Creek (Sullivan and Richardson 1993), although herpetological surveys have not located the species to date in either West Clear Creek or Wet Beaver Creek (pers. comm. Andrew Holycross).

Mexican Garter Snake (*Thamnophic eques megalops*)

The Mexican garter snake is usually found in or near streams and ponds in canyons up to 6,200 feet in elevation. This garter snake is most closely linked to shallow slow-moving or impounded waters, though it also occurs in other aquatic environments. The Mexican garter snake's diet consists of leopard frogs, toads, tadpoles, and various native fishes. Lizards and small rodents are taken during occasional terrestrial forays. The Mexican garter snake is known to be associated with leopard frogs which are a major prey species. Mexican garter snakes have been sighted along the Verde River and several of its tributaries but there are no known sightings or specimens from the Fossil Creek drainage. Erika Nowak, USGS herpetologist, has indicated that Fossil Creek riparian is potential habitat for the Mexican garter snake. Andrew Holycross, herpetologist with Arizona State University indicates that the lower few miles of Fossil Creek may provide habitat for the Mexican garter snake if the water is relatively slow moving, not too cold, and contains well-vegetated banks (pers. comm. Andrew Holycross).

Arizona Night Lizard (*Xantusia vigilis arizonae*)

In central Arizona, the Arizona night lizard ranges from the western slope of the Central Plateau (Weaver, McCloud, and Superstition Mountains, Tonto National Monument, and Valentine), in Haulapai, Harquahala, Kofa, and Castle Dome Mountains, and at other scattered localities (Stebbins 1985). Habitat for this secretive lizard is arid or semiarid lands, where it lives beneath fallen brances of Joshua trees, dead clumps of various other species of yucca, nolina, agave and cardons and is also found in rock crevices, beneath cow chips, soil-matted dead brush and other debris, and beneath logs (Stebbins 1985). Arizona night lizards are seldom found in the open away from cover (Stebbins 1985).

No surveys have been done in the project area for this species and there are no known records of its occurrence. However, it is listed as a fairly common, permanent resident of desert scrub and grasslands on the Coconino National Forest.

Restoration Goals and Objectives

The restoration goals and objectives specifically related to the lowland leopard frog in Fossil Creek include maintaining the existing breeding population of leopard frogs in Fossil Creek above the Fossil Springs Diversion Dam, allowing for the development of riparian habitat downstream of the Fossil Springs Diversion Dam, and reestablishing a sustainable population of lowland leopard frogs below the Fossil Springs Diversion Dam. The native fish restoration project began this process by removing non-native fishes from approximately 9 miles of the creek. In addition, the return of full flows to the creek will result in habitat changes downstream of the diversion dam. It is anticipated that once full flows are restored to Fossil Creek, the buildup of travertine and the resulting formation of pools and aquatic vegetation will allow for populations of leopard frogs below the dam to become established and to persist. However, the lack of locations at historical sites (Sredl et al. 1995a) and the disappearance of leopard frogs from occupied sites combined with the frog's susceptibility to local extirpation and the presence of predators (e.g., crayfish) is reason for concern. Monitoring the development and/or loss of lowland leopard frog habitat is important to the management of the frog in Fossil Creek. In addition, the Fossil Springs Diversion Dam removal may adversely impact frogs currently utilizing the pool above the dam. Monitoring should track the presence/absence and distribution of frogs prior to, during, and after the removal of the dam.

Restoration goals for the sensitive reptiles are to ensure water quality within Fossil Creek and habitat quality both within the creek and within adjacent riparian areas. Of particular concern for the Arizona toad, narrow-headed garter snake and Mexican garter snake, if they are found to be present in Fossil Creek, is the requirement for slow moving backwater areas that are necessary for nursery habitat. It is unknown if the restoration of full flows will allow for the presence of such backwaters. It is very likely that, as travertine dams and pools form after the return of full flows, these backwaters may develop over time. These backwaters need to be at least a meter or more in size, have slow moving water, warmer water, and vegetation on the stream bank (pers. comm. Erika Nowak). There is a significant correlation between the presence of backwaters and young of these species. If these backwater areas are not present, young of the Arizona toad and the two gartner snakes will not be able to survive in Fossil Creek.

A further concern is the very real potential for recreational impacts to these backwater areas. Recreationists are attracted to such areas and this can result in trampling of vegetation and soils, resulting in bank compaction, erosion, and the creation of cut banks (pers. comm. Erika Nowak). Recreation can also increase silt loads which leads to decreased dissolved oxygenation of the interstitial areas where fish lay their eggs and affects the spaces between rocks used for foraging by narrow-headed garter snakes (Nowak and Santana-Bendix 2002). It has been suggested that heavy siltation will negatively affect narrow-headed garter snake populations due to this loss of prey microhabitat (Nowak and Santana-Bendix 2002). A further threat to the narrow-headed garter snake is direct killing by people because this snake looks similar to the poisonous water moccasin (pers. comm. Erika Nowak). A method that has been suggested for use within habitat for the narrow-headed garter snake in Oak Creek, Arizona is the installation of signs at developed areas with pictures of the snakes and information about their status and biology (Nowak and Santana-Bendix 2002).

Although bull frogs have not been observed in Fossil Creek except for near the confluence with the Verde River (pers. comm. Shaula Hedwall, fish and wildlife biologist, U.S. Fish and Wildlife Service), expansion of this non-native frog further into

Fossil Creek has the potential to negatively affect the lowland leopard frog, the Arizona toad, and the narrow-headed and Mexican garter snake.

Monitoring and Indicators: Lowland Leopard Frog

Trends and Implications of Monitoring to Date

The Arizona Game and Fish Department, EnviroNet Inc., the U.S. Fish and Wildlife Service, and the U.S. Forest Service have conducted surveys for leopard frogs in Fossil Springs, Fossil Creek, and stock tanks within the Fossil Creek drainage. All life stages of lowland leopard frogs have been observed in abundance above the dam in the Fossil Springs area. Below the dam, lowland leopard frogs were found near the Coconino National Forest Boundary in 1950, but not in 1985, 1990, 1992, or 1995. Surveys conducted in 1998 by EnviroNet, Inc. did not locate any leopard frogs from the bridge to the Irving Power Plant, nor further upstream to approximately 3,840 feet elevation. Abundant metamorphic stages of tadpoles were observed from a spring at 3,840 feet elevation throughout the stream channel upstream to the Fossil Springs Diversion Dam. In 1998, no crayfish were observed above the 3,840 feet elevation mark where tadpoles were numerous. EnviroNet, Inc. surveys did locate a few immature lowland leopard frogs in a small side pool, upstream of the Fossil Creek confluence with the Verde River. Several lowland leopard frogs were observed by Manuel Santana-Bendix (Northern Arizona University) while conducting reptile surveys in Fossil Creek in 2004 and agency biologists observed several subadult frogs below the Fossil Springs Diversion Dam but above the "sunfish barrier"[17]. Despite these few recent observations, the few numbers of frogs observed below the Fossil Springs Diversion Dam indicates that populations below the dam are currently unsustainable. This is most likely due to the presence of predacious non-native fish and crayfish species.

Recommendations for Future Short- and Long-Term Monitoring

For lowland leopard frogs, the objectives of the "Monitoring and Adaptive Management Strategy for Special Status Species and Habitat Associated with the Childs-Irving Project Decommissioning" (Childs Irving Document Number CI-CP-18, November 15, 2004) prepared by the Forest Service, U.S. Fish and Wildlife Service, and Arizona Public Service are: 1) to monitor the distribution of lowland leopard frogs prior to, during, and after the removal of the Fossil Springs Diversion Dam along the length of Fossil Creek; 2) to monitor the persistence of the existing leopard frog population throughout the decommissioning process; and, 3) to monitor the development of riparian habitat downstream of the Fossil Springs Diversion Dam prior to dam removal. The protocols and process for determining these objectives are outlined in the Monitoring Strategy. If information indicates that the lowland leopard frog is declining and habitat is not developing downstream, the removal of the Fossil Springs Diversion Dam may be modified.

Monitoring and Indicators: Arizona Toad, Narrow-headed Garter Snake, and Mexican Garter Snake

Some baseline inventory work has been completed for reptiles in Fossil Creek (by Manuel Santana-Bendix, NAU), however it is not complete (pers. comm. Erika Nowak). Therefore, the first priority for monitoring of these species is to complete baseline inventory work and determine if these sensitive species are present at Fossil Creek. It is expected that completing the baseline inventory work would take minimal time and expense given that some of this work has already been completed.

Monitoring should take place in the form of determining if nursery habitat for these species is present, to what extent, and determining if such habitat is being impacted by recreational use. Because both the narrow-headed and Mexican garter snake populations are in decline throughout Arizona, monitoring for both the presence of these species and the condition of habitat for these species should be the priority in Fossil Creek (pers. comm. Erika Nowak). Impacts to nursery habitat for these snakes and the Arizona toad is the most significant threat to these species (pers. comm. Erika Nowak).

If inventory and monitoring indicate that these species are present and that this important habitat is impacted negatively by recreational use, we recommend considering fencing and information signing of some of these areas. While we understand that fencing is a time-consuming activity given the potential for large flood flows in Fossil Creek, the long-term viability of these species in Fossil Creek may require such methods.

Because of the significant potential harm to these native species that will result from the presence of bullfrogs, we recommend monitoring of the movement of bullfrogs upstream into Fossil Creek and the implementation of appropriate removal methods if they are found to be expanding further into Fossil Creek.

The presence of the lowland leopard frog and the health of the population will be an indicator of the water quality and relative health of the Fossil Creek riparian area. Frogs are some of the best indicators of habitat health, and thus, careful attention should be paid to the health of the lowland leopard frog in Fossil Creek.

If the Arizona toad, narrow-headed and/or Mexican garter snakes are located in the Fossil Creek drainage, their continued presence will be an indicator of the health and condition of the riparian area and in particular, nursery backwaters.

Invertebrates

Janie Agyagos and Michele James

All of the invertebrates discussed in this section are special status species.

Fossil Springsnail (Pyrgulopsis simplex)

Although an aquatic species, the Fossil springsnail is discussed in this section with the other special status invertebrates (it is also discussed to a limited extent in the Macroinvertebrates section of this report). Springsnails of the genus *Pyrgulopsis* typically occur on rock or aquatic macrophytes in moderate current. The Fossil springsnail is typically found only in the headspring and upper sections of the outflows at the various Fossil Springs. Because springsnails are minuscule in size, and have only a partial operculum, they cannot withstand any desiccation, and occur only in water that is perennially flowing. In addition, there is evidently some chemical requirement that causes them to occur only in the very headwaters of a spring. The Forest Service indicates that the Fossil springsnail has experienced no apparent reduction in range or abundance as a result of activities in the Fossil Creek watershed during the past two decades.

Maricopa Tiger Beetle (*Cicindela oregona Maricopa),* and *A Tiger Beetle (Cicindela hirticollis corpuscular)*

Tiger beetles prefer open sandy areas, often along bodies of water. They construct burrows in the sand which they use for refuge. Tiger beetles lay their eggs in tiny vertical shafts in the sand.

The Maricopa tiger beetle (*Cicindela oregona maricopa*) frequents the edges of lakes and streams (Papp 1979). It is found from California to New Mexico and has been found in 10 Arizona counties including Yavapai. Adults are active from April to October and are found along streams (Bertholf 1983).

The *Cicindela hirticollis corpuscula* subspecies of tiger beetle occurs in the southwest from Texas to California (Bertholf 1983). Although Bertholf does not list Yavapai County among the 7 counties in Arizona where the species has been recorded from the state, it has been found in counties all around Yavapai County, suggesting its possible occurrence in the Fossil Creek area. Adult tiger beetles can be found from April to November.

Terrestrial Ecosystem Survey soil data was queried for a variety of sandy soil types in order to determine potential habitat for both species of tiger beetle. Sandy soils are present along Fossil Creek from where the road crosses Fossil Creek below Irving downstream to its confluence with the Verde River (Zones 4 and 5) and along the entire portion of the Verde River in proximity to Fossil Creek. Sandy soils are also present in the uplands but since these species occur near water, it is not anticipated that they would occur in the upland areas since no springs, seeps, or tanks are present.

Freeman's Agave Borer (Agathymus baueri freemani), Neumogen's Giant Skipper (Agathymus neumoegeni), and, *Aryxna Giant Skipper (Agathymus aryxna)*

The genus *Agathymus* is in the Aegialini tribe of the subfamily Megathyminae, which are collectively known as the giant skippers. These are the only butterflies whose larvae exclusively bore into flesh leaves or roots. Larvae of the Megathyminae have adapted to feeding only on plants of the Agave family.

The larvae of the Aigailini tribe feed exclusively on agaves and are known as the trapdoor giant skippers because of the silken trapdoor that larger larvae construct over the opening to their burrow in an agave leaf. Eggs are laid on or near the host plant. Young larvae bore into the leaf tips and eat pulp within the leaf and then hibernate there. The following season, the third-stage larvae move down to the base of the leaf where they bore in again. They continue eating pulp and later sap in a chamber in the leaf base, silking over the opening in the leaf after each molt. Mature larvae stop eating, remain quiescent for a period of time, then powder the inside of the chamber and construct a silken trap door at the opening to this nest cavity. Here the larvae pupae emerge as adult butterflies. The adult butterfly stage is short, lasting one to two weeks during which time it breeds, lays eggs, and dies. The adult butterflies do not feed on flowers nor do they migrate. They can often be found feeding near mud or manure, or perching on the host plant, other bushes, or on rocks (Scott 1986).

The Freeman's agave borer is found in Mohave and Sonoran desertscrub of central and southwestern Arizona. It inhabits canyons, and requires agave host plants, specifically, *Agave chrysantha* (Pyle 1981).

The Neumogen's giant skipper has been reported from the upper Sonoran deertscrub or lower Transition Zone in open woodland or shrub-grassland habitats, where its host plant is *Agave parryii* and probably *A. chrysantha* (Wallesz 1999; Opler et al. 1995). Larvae are found on small host plants (Scott 1986). Pre-pupating larvae make the trapdoor of the nest cavity on the upper side of the leaf-base. There are confirmed record of the *A. neumoegeni* complex from Coconino and Yavapai Counties (Wallesz 1999).

The Aryxna giant skipper is found in upper Sonoran desertscrub and semi-desert grasslands into petran montane coniferous forests. Habitat for the Aryxna giant skipper is arid but well vegetated desert canyons (Pyle 1981), or canyons with periodic water and open grassy woodlands (Opler et al. 1995). The caterpillar host is *Agave palmeri*, *chrysantha*, and *deserti*. These species make the trapdoor on the underside of the leaf-base. Adult females never feed and adult males sip water from mud (Opler et al. 1995).

TES soil mapping units were queried for agave host plants. Almost all of the soils within the Fossil Creek watershed support at least one species of agave, therefore, most of the area is potential habitat for these three giant skippers (Table 19). Surveys for these three species have not been conducted, and population status within the watershed is unknown.

Blue-black Silverspot Butterfly (Speyeria nokomis nokomis), Mountain Silverspot Butterfly (S.n. nitocris)

The mountain silverspot and blue-black silverspot are riparian dependent butterflies. The larvae of both silverspots feed on species of Viola while the adults feed on thistle nectar. No surveys have been conducted within the Fossil Creek watershed and the population status is unknown. TES soil map units were queried for Viola and thistle plants. Mapping results show very few areas with soils that could support these host plants (Table 19). Within the watershed, there are three small pockets of potential habitat along Fossil Creek and along Mud Tank Draw.

Obsolete Viceroy Butterfly (Limenitis archippus obsolete)

The obsolete viceroy butterfly is a riparian dependent butterfly. The larvae and adult form of the obsolete viceroy feed on leaves, twigs and other plant parts of host species including willow and cottonwood. No surveys have been conducted within the watershed and the population status is unknown. TES soil map units were queried for willow and cottonwood species. Mapping results show potential habitat for this species occurs all along Fossil Creek, the Verde River, Sally May Wash, Tin Can Canyon, and Boulder Canyon.

Early Elfin (Desert Elfin) (Incisalia fotis)

This hairstreak butterfly favors roadsides with flowers (Borrer and White 1970), dry areas in mountains (Schneck 1990), and desert, rocky canyons, hills, and scrub (Opler et al. 1995). The host plant is cliffrose (Schneck 1990). According to Ferris and Brown (1981), they are locally uncommon among arid plateaus and desert mountains from 6000-7000 feet. In Arizona, the early elfin's range may be restricted to the northern portions of Coconino County (Wallesz 1999), making its presence in the watershed unlikely, however, no surveys have been conducted for this species.

No surveys have been conducted within the Fossil Creek watershed and the population status of this species is unknown**.** TES soil mapping units were queried for its main host plant, cliffrose.

Comstock's Hairstreak (Desert Green Hairstreak) (Callophrys comstocki)

This hairstreak butterfly occurs in desert ranges of southern California, largely in the Mojave Desert, also in parts of Nevada, Arizona, and Utah. The species favors dry, rocky areas (Schneck 1990) of foothills and canyons of the Upper Sonoran Mountain plateaus from 5000-6000 feet (Ferris and Brown 1981). Opler et al. (1995) give Comstock's hairstreak's habitat as sagebrush scrub and pinyon-juniper woodland. Larval host plants are various wild buckwheats (*Eriogonum*) (Schneck 1990; Ferris and Brown 1981; Opler et al. 1995).

No surveys have been done for this species in the watershed. In Arizona, there are confirmed records only in Navajo and Mohave Counties. TES soil mapping units were queried for this species main host plant, *Eriogonum*.

Spotted Skipperling (Piruna polingii)

The habitat of the spotted skipperling consists of moist meadows and streamsides in low to mid elevation mountains. In southeast Arizona, this species takes nectar avidly along cool, deep canyons and along forested road margins. The species has been seen congregating on moist cliffsides. *Dactylis glomerata* (Poaceae) is a strongly suspected food plant. While extensive plant surveys have occurred in the riparian area associated with Fossil Springs and creek, there has been one survey conducted in the uplands. *Dactylis glomerata* was not found in any plant surveys conducted in the watershed. Despite this, grassing openings with various species of grasses are present throughout the pinyon juniper, ponderosa pine, and mixed conifer vegetation types. Therefore, it appears that there is an abundance of potential habitat for this species in the watershed. The vegetation coverage was queried for pinyon-juniper, ponderosa pine, and mixed conifer to determine potential habitat within the watershed (Table 19).

Netwing Midge (Agathos arizonicus), Hoary Skimmer (Libelula nodisticta), and, *Arizona Snaketail (Ophiogomphus arizonicus)*

Sensitive aquatic invertebrate species that may occur in Fossil Creek include the netwing midge, hoary skimmer, and Arizona snaketail. All require perennial water, however, the hoary skimmer is associated with still water, the netwing midge prefers swift moving waters associated with waterfalls, and the snaketail occurs in stream habitat rather than pond habitats where it burrows underneath debris on the stream bottom. These species may occur in Fossil Creek and the Verde River where the appropriate stream geomorphology is present.

Table 19. Potential habitat for various sensitive invertebrates based on host plant presence within the Fossil Creek planning area. (Table from U.S. Forest Service, Coconino National Forest.)

Species Name	Habitat in the Planning Area	Percentage of Habitat Within the Planning Area
Maricopa Tiger Beetle	4,632	2.42
Tiger Beetle	4,632	2.42
Freeman's Agave Borer	601	0.31
Aryxna Giant Skipper	19,909	10.40
Neumogen's Giant Skipper	19,308	10.08
Blue-black Silverspot Butterfly	126	0.07
Mountain Silverspot Butterfly	126	0.07
Obsolete Viceroy	741	0.39
Early Elfin	17,016	8.89
Comstock's Hairstreak	12,382	6.47
Spotted Skipperling	21,563	11.26
Netwing Midge	113	0.06
Hoary Skimmer	113	0.06
Arizona Snaketail	113	0.06

Restoration Goals

The Fossil springsnail occurs only at outflow locations of the numerous springs in the Fossil Springs area. The Forest Service indicates that the springsnail has not been impacted by the activities in the watershed over the last 20 years. The range and abundance of this springsnail prior to diversion of flows in Fossil Creek is unknown. Restoration goals for the Fossil springsnail are to ensure no loss of habitat at the springs and to preserve the water quality in and around the springs. Of concern are recreational activities at the various springs which can directly impact the springsnail through handling and stepping upon the rocks to which the snail attaches itself, crushing the snails. Recreational activities can also affect the vegetation around the springs and increase the potential for negative effects to water quality. Access to the springs should be carefully monitored and limited if monitoring indicates impacts to this snail.

Although the presence or absence within the watershed of the majority of the sensitive invertebrates is unknown at this time, aquatic habitat provided by Fossil Creek is of importance to many of these species (two subspecies of tiger beetle, two subspecies of silverspot butterflies, the obsolete viceroy butterfly, spotted skipperling, netwing midge, hoary skimmer, and Arizona snaketail). Restoration goals for these sensitive invertebrates are to ensure water quality within Fossil Creek and habitat quality both within the creek itself and within the riparian area. Recreational activity has the potential to negatively affect water quality as well as riparian vegetation.

Monitoring

Because recreational use at Fossil Springs could potentially negatively affect the sensitive Fossil springsnail, we recommend that monitoring of this species be given a high priority. Monitoring of the Fossil springsnail should occur at regular intervals to determine if recreation is resulting in negative impacts to the snail and its habitat. Because recreational use is expected in increase with the return of full flows to Fossil Creek, we recommend that monitoring begin as soon as possible so that any impacts can be identified and immediate action taken if necessary. We recommend the development of a monitoring protocol and plan specific to the Fossil springsnail by the end of 2006 or earlier.

While habitat is present in the watershed for these 14 sensitive invertebrates, surveys have not been conducted in the area. The first step in monitoring then is to conduct presence/absence surveys. We recommend that these surveys be conducted for the invertebrates most at risk of potential negative effects related to restoration of Fossil Creek, namely recreational activity. Surveys should be conducted in places where recreational activity is currently occurring or where it may occur given the predicted increase in visitation as a result of return of full flows. While we believe such surveys are important, we suggest that monitoring for the springsnail, as discussed above, be given priority.

Indicators

The presence of the Fossil springsnail and health of the population is an indicator of the relative health of the spring outflows in Fossil Creek. In particular, these factors indicate the health of the habitat associated with the springs as well as the overall water quality. If the springsnail population is considered healthy at the spring outflows where recreational use may impact on the species, this will be an indication that recreational use is at a benign or acceptable level. Conversely, if the springsnail population is not healthy despite the presence of suitable habitat and water quality, this will be an indication of recreational use at a level that is incompatible with the habitat needs of this species.

The presence of and health of sensitive invertebrate populations that may be present in the Fossil Creek watershed could be affected by a variety of factors. For those invertebrates that are present in the watershed within or adjacent to Fossil Creek, an indication of their health will be the condition of the riparian area and water quality. Recreational activity occurs both within the riparian area, with the creek itself, as well as within the upland portions of the watershed. The presence of a given invertebrate may assist in determining the health of a particular habitat type within the watershed.

Humans and the Social Environment

Cultural and Archeological Resources

Sharynne-Marie Blood and Scott Wood

Introduction

The historic and cultural resources of the Fossil Creek watershed consist of those prehistoric and historic archaeological sites and historic structures within the watershed, including those areas identified as having traditional or religious significance by the Indian tribes who lived there historically.

Archaeological investigations have been conducted in the Verde Valley and the Fossil Creek drainage beginning in 1890 when Dr. E. A. Mearns, U.S. Army, published a brief account in Popular Science Monthly (Mearns 1890) of Indian ruins in the Verde Valley. In 1891, Cosmos Mindeleff, Bureau of American Ethnology (Mindeleff 1896), followed the River Trail from what is now Horseshoe Dam to Camp Verde, recording prehistoric ruins, irrigation works, and a series of natural and artificial caves ("cavates") along the way. Several of these sites are within or adjacent to the Verde Wild and Scenic River corridor. In 1928, Frank Midvale, Gila Pueblo Foundation, made a similar journey, recording several of the same sites as Mindeleff had along with a number of others (Gladwin & Gladwin 1930). These efforts focused on recording the large masonry ruins that represented a substantial residential occupation in the later prehistoric period. Neither survey could be considered any more than a preliminary reconnaissance.

Since the 1970's, periodic surveys by Forest Service archaeologists from the Tonto and Coconino National Forests in support of trail work, fence construction, and other small scale activities have added to the inventory. Forest Service archaeologists from the two Forests have also made occasional condition inspections of sites within the planning area, focusing on several of the better known and accessible sites.

Since then, the primary archaeological survey of the project area was conducted by Archaeological Consulting Services (ACS) to provide specific planning information for a Memorandum of Agreement that would provide for the continued operation of the Child's-Irving Hydroelectric power project (Macnider et al. 1991). An important result of this archaeological survey was the nomination to and listing on the National Register of Historic Places of the Child's-Irving Hydroelectric power project. The listing acknowledged the importance and significance of the hydropower facilities, not only the elements included as contributing but also the entire historic landscape that dominates the Fossil Creek corridor.

While providing comprehensive information about sites along the flume corridor, the inventory did not provide sufficient information to adequately inform management decisions regarding land use within the entire Fossil Creek Planning Area. In order to better inform this environmental analysis, an archaeological and ethnohistorical study was contracted by the Forest to SWCA, Inc. This study included an archival review of existing literature, interviews with tribal cultural specialists, and field inspections with the tribal cultural specialists of specific sites along Fossil Creek. Additionally, an interpretive plan for the hydropower facilities as well as the prehistoric sites within the planning area was prepared.

Current Knowledge of Historic and Cultural Use

The Fossil Creek planning area is known to contain archaeological evidence of the occupation and agricultural use and modification of the Fossil Creek floodplains, terraces, and hill slopes by people of the prehistoric Southern Sinagua cultural traditions over a period of at least 600 years. It may contain sites of human use and occupation from as long ago as 8,000 to 10,000 years.

It is also expected to contain a number of pre-European contact and historic sites reflecting use by Yavapai and Apache hunters, gatherers, and farmers and by European, Mexican, and Euro-American stockmen who raised or drove cattle and sheep throughout the area. It also contains a significant[18] part of the industrial history of Arizona, as it contains the site of the earliest hydroelectric generating system in the State at the small settlements of Childs and Irving, currently still occupied. The significance of the Childs and Irving power plants has already been recognized by listing the sites in the National Register of Historic Places and the American Society of Mechanical Engineers who recognized the system's historic engineering and construction significance by selecting it as the 11th National Historical Mechanical Engineering Landmark.

Archaeological surveys, including an assessment of the Childs-Irving Hydroelectric System (Macnider et al. 1991) have identified a wide range of features embedded into the Fossil Creek analysis area landscape, including nearly invisible scatters of discarded artifacts and trash, collapsed and buried pit houses, intact cliff dwellings and ruins exceeding 20 rooms in size, and buildings collapsed into masonry rubble piles up to two meters high.

The great majority of these features are prehistoric in date and consist most frequently of collapsed stone masonry structures of various sizes, stone-built water control devices, pit ovens for preparing plant and animal foods, and petroglyphs, rock art hammered into the surfaces of boulders and basalt outcrops (Macnider et al. 1991).

No specifically located ethnographic resources, traditional cultural properties, native plant gathering areas, sacred sites, or other significant Tribal places have been securely identified within the Fossil Creek planning area (Neal 2003). Nevertheless, portions of the Fossil Creek planning area fall within the traditional territories of the Bald Mountain and Fossil Creek Bands of the *Dil zhéé*, or Tonto Apache, as well as different groups of Yavapai. At least eight *Dil zhéé* clans, some mixed with Yavapai, are known to have inhabited portions of the planning area or kept farms there. Several may have originated in the Fossil Creek drainage. In addition, the *Dil zhéé* maintain many place names associated with features in and adjacent to the Fossil Creek planning area (North et al. 2003). Although specific sites with evidence of Apache or Yavapai occupation are fairly well represented in the current inventory, they can be expected to be found in greater numbers with additional survey and closer inspection of known sites for evidence of

Apache or Yavapai reoccupation. Likewise, as additional information can be gathered through interviews with tribal elders, specific locations may yet be identified that correspond to historic farms and camps.

Condition of the Historic and Cultural Resource Inventory of Fossil Creek

In general, it can be said that archaeological knowledge of the cultural resources within the planning area are poorly understood, with less than 3% of the area having been inventoried to current standards.

One hundred sixty-eight (168) archaeological and/or historic sites have been recorded or reported within or immediately adjacent to the Fossil Creek analysis area. The previous inventories were dominated by the larger, more permanent stone masonry residential sites with few other site types represented and the ACS study focused on the hydropower corridor (Macnider et al. 1991).

Twenty-seven of the 168 archaeological sites (16%) are now noted as permanent prehistoric residential settlements, ranging in size from small homesteads of one or two rooms to large masonry room blocks and outliers containing perhaps as many as 40 contiguous rooms. At least six of these are large, early pit house settlements. Another 42 (25%) are said to have been temporary prehistoric residential sites, usually one room structures known as “field houses”.

Twenty-three prehistoric artifact scatters without masonry or other visible surface features or indications of subsurface pit houses are recorded and only nine prehistoric sites are described as defensive in either architecture or location. There are also a variety of prehistoric agricultural features associated with many of the residential sites.

There are 38 historic sites, all related to hydroelectric power generation, roads, trails, or ranching. With the exception of one hydropower related site and a few of the prehistoric agricultural sites, all of the historical and cultural sites inventoried in the analysis area, prehistoric and historic alike, are located outside the zone of riparian vegetation and scouring floods on the terraces, ridges, and hills overlooking the creek.

Site condition throughout the analysis area is highly variable. All of the large prehistoric pueblo sites could be characterized as having more than half of their recognizable features vandalized. Site impacts include looting, vandalism, erosion, alteration of site context, disturbance from management activities and recreation, disturbance from APS construction and maintenance activities, damage to tribal values, and disturbance from stock grazing. Overall impressions of the remainder of the inventoried sites suggest that they are generally in good condition.

Given the high level of site integrity and the significance of the settlement history of this area, all inventoried sites within the watershed are currently considered eligible for the National Register of Historic Places, pending further evaluation. Two sites are listed on the National Register, site AR-03-04-01-11, the Irving System, and site AR-03-04-01-12, the Childs Power System. Both sites were nominated and listed together as one Historic District, August 9, 1991.

Goals

The Forest Service is required by law and regulation to protect and preserve historic and cultural resources from damage, excessive deterioration, vandalism, looting, and the alteration of site context. The primary causes of impacts to historic and cultural resources in the Fossil Creek planning area are vandalism and looting. Damage from recreational activities is another potential source of impact. Thus, the primary goals following restoration of full flows to Fossil Creek are protection and preservation of cultural and historic properties from the expected increase in visitation.

Historic and cultural resources are best protected from vandalism and looting by active management, particularly observation and monitoring. This can be provided by Forest Service personnel inspecting sites on a regular basis, or by volunteer organizations such as the Arizona Site Stewards who perform a similar function. Recreational visitors can also keep an eye on each other, although this method requires that visitors be informed and aware of the consequences of looting and vandalism. Where roads and trails provide proximate access to historic and cultural sites, they can be more easily and frequently patrolled and monitored.

Vandalism and looting are impacts arising from intent, generally with foreknowledge that such activity is illegal. Passive methods of protection, including restricting access by physical barriers such as fences or by on-site notification and education signs, are effective only when combined with active observation and monitoring. In remote locations, where there is little concern that illegal activities will be observed, passive measures are easily and anonymously defeated. Contrary to conventional wisdom, lack of access is no deterrent to vandalism or looting.

These conclusions result from many years of observation by Forest Service and other land managers in Arizona over the last 30 years. It also derives from several decades of active participation in the Arizona volunteer Site Stewards program operated by the State Historic Preservation Officer. Since that program began, vandalism has decreased appreciably on the Tonto and Coconino National Forests. This decrease appears to correlate directly with increases in site visitation and monitoring by the Site Stewards. There is also a direct and very dramatic correlation between frequency of site visitation by the public and the reduction of vandalism, even at remote locations, a result of combined efforts by both Forests to interpret sites and expand public education and appreciation of heritage values. Vandalism also decreases in areas that are regularly patrolled by Forest Service Law Enforcement Officers. These observations form the basis for continued support of both the Site Steward program and the development of interpretive visitor facilities at major sites by land managers throughout Arizona. Reducing vehicular access to portions of the Fossil Creek planning area may also reduce the ability of Forest Service personnel and volunteer Site Stewards to monitor the condition of sites within the planning area and to enforce laws protecting them from vandalism and looting. Reduction of access would also result in reduced visitation in general, resulting in fewer potential observers of all kinds. Finally, reduction in vehicular accessibility increases law enforcement response time and costs.

High levels of recreation use may affect the integrity of historic and cultural resources as visitors expand use areas outside the established access points and campgrounds. Informal camping areas within site boundaries can impact site integrity through the introduction of modern trash, the removal of architectural materials to construct fire rings, and the digging of holes for disposing of waste. Other direct effects of camping on sites include the casual collection and displacement of surface artifacts and the establishment of informal trails that can initiate destructive gullying erosion. Camping on archeological sites, digging trenches around tents during the rainy season, digging shallow holes to bury garbage, repeatedly driving tent stakes into the surface of the site has a direct effect on site integrity. Indirect effects of camping on sites may include increased vandalism encouraged by the presence of fire rings and trash as an indicator that the sites might not be closely monitored or maintained. Protection from recreational activities can be achieved by a variety of methods. Active observation is effective, but requires a constant presence of Forest Service personnel in the area. Passive methods do not work nearly as well but are often considered cost effective under restrictive budgets.

It would be possible to provide opportunities for interpreting cultural and historic resources and educating visitors regarding rules of conduct when visiting and the laws and regulations protecting them. Patrol and monitoring of the area by Site Stewards would improve the effectiveness of historic and cultural resource law enforcement in the area.

Monitoring and Indicators

The archaeological monitoring and evaluation program is the management control system governing the implementation of the FCEIS. The program is designed to be the foundation for the long-term protection and enhancement of the primary creek-related values in the planning area. The specific objectives of this program are to determine whether:

- Future desired conditions are achieved;
- Management standards are being followed;
- Management standards are effective in protecting and enhancing the ORVs;
- Intensity of monitoring is commensurate with the risks, costs, and values involved in meeting desired conditions.

The monitoring activities described in Table 20 below are designed to be specific to the Fossil Creek area and are to be conducted in addition to other monitoring activities prescribed in the Coconino and Tonto Forest Plans. Implementation of the following monitoring elements will be based on the availability of funding. If adequate funding is not available some monitoring activities may not take place. Both National Forests involved with management of Fossil Creek will make every effort to identify opportunities that would reduce the actual cost to the government. The following table outlines the key indicators, resource conditions, sampling procedures, and typical resultant management actions that will be conducted on Fossil Creek by creek value.

There are no specific plans or directions for historic and cultural resources within the Fossil Creek planning area proposed by either of the existing Forest plans, though each contains objectives, standards, and priorities for the inventory, evaluation, protection, and enhancement of historic and cultural resources.

Under this management direction historic and cultural sites are to be preserved in place as the first priority for management, stabilized and repaired whenever possible, particularly when they have been damaged by vandalism, and provided with interpretation and other enhancements where appropriate and feasible.

Table 20. Summary of the Forest Service's Fossil Creek planning area monitoring program.

Value to be Maintained and Enhanced	Key Indicator	Resource Condition	Sampling Procedure and Frequency	Management Actions to be Triggered if Conditions are Not Met
Archaeological and Historic Site Integrity	Artifact Loss or Displacement due to Theft or Visitation	Surface artifact assemblage remains substantially intact with no more than 25% of baseline documented surface artifacts removed or destroyed.	Inspections of high probability and frequently visited sites by river rangers, minimum of once per year; Periodic inspections by heritage specialists; Additional inspections by volunteer site stewards as available.	Collect and curate appropriate sample of remaining artifacts and all diagnostic artifacts; Post site with protection message
	Contextual Damage	Standing or coursed masonry walls remain intact without damage from visitor use. Features and rock art remain free from vandalism. Sites remain free of evidence of recreational activities such as fire rings, trash, and unauthorized trails.	Inspections of high probability and frequently visited sites by Law Enforcement Officers, minimum of once per year; Periodic inspections by Heritage Specialists; Additional inspections by volunteer Site Stewards as available.	Stabilize and repair architectural and/or pothunting/vandalism damage; Remove trash, fire rings and obliterate trails; Post site with protection message; Establish temporary, seasonal, or permanent closures to prevent visitation of sensitive sites after repeated contextual damage impacts.
	Natural Damage	Features and cultural deposits remain substantially intact with no more than 10% damaged by natural erosion and no more than 5% removed by natural erosion. Features and cultural deposits remain substantially intact with no more than 25% damaged or removed by animal burrowing, trailing, or feeding.	Inspections of high probability and frequently visited sites by Law Enforcement Officers, minimum of once per year; Periodic inspections by Heritage Specialists; Additional inspections by volunteer Site Stewards as available.	Stabilize and repair erosional or animal caused damage; Redirect runoff away from erosionally sensitive features or cultural deposits; Identify and implement measures to redirect animal attraction to the site

The Yavapai-Apache Nation: A Brief Synopsis of Ancestral Ties to Fossil Creek

Christopher Coder and Vincent Randall

The Yavapai-Apache Nation is the modern amalgamation of two culturally distinct Tribes: (1) the Athapaskan speaking Dilzhe'e People (popularly known as Tonto Apaches) and (2) the surviving remnants of Yuman speaking Wipukapaya and Tolkapaya People, amongst others collectively known today as Yavapai. The Yavapai-Apache Tribe was formed by the federal government in 1934, under the Indian Reorganization Act, and recognized by the Secretary of the Interior as a formal political entity with the approval of the Tribal Constitution in 1937. The official status was changed to Yavapai-Apache Nation in 1992 in order to pay due respect to the two different cultures, which were formed into a single Native American Nation. In 'Old Apache' language, the term Dilzhe'e means, 'to go hunting' or 'going hunting' and that is the reputation these Western Apache People had amongst their surrounding neighbors and trading partners. Yavape'/Yavapai, means 'People of the Sun'.

In a confusing mixed-bag of recognition, there are several tribes around the state, including the descendents of Western Apache and or Yuman speaking "Yavapai" People. The modern San Carlos Apache Reservation was the nineteenth century site selected for the location of the concentration camp containing virtually all the western Apache groups, including the Dilzhe'e, as well as the various bands of Kevewekepaya, Tolkapaya, Wipukapaya and Yavape' (all collectively equal the Yavapai) who were hunted down and rounded up mostly west and south of the Verde River.

At the time of the federal conquests in central Arizona (1865-1873) the Dilzhe'e were in control of the lands east and north of the Verde while the Yuman speaking Wipukapaya held sway in the mountains directly to the west and south in the vicinity of Fossil Creek on the opposite side of the Verde. The Verde River was not construed by these people as a hard and fast boundary, but more as a frontier zone. The river corridor was used by both groups, who despite their linguistic and material differences, had cordial relations at the band and family levels, where they interfaced along the Middle and Upper Verde. Because of several factors held in common – similar procurement zones along the Verde, common trading partners (the Hopi) to the northeast, and common enemies to the south (the Pima, Papago and Maricopa's) – bands of these two People often collaborated because of their small numbers for defense, raiding and retribution.

We do not agree with the "one culture at a time only" model of southwestern cultural history. We believe in a more complicated and multicultural approach to the use of the landscape over time and, of course, this is not the place to elaborate. Suffice it to say families and bands of Yuman speaking Peoples have expanded and contracted into and out of the region for millennia in response to numerous factors and the Western Apaches have been entrenched in the countryside east of the Verde for centuries.

By the time Mexico ceded its Old Imperial Spanish lands to the United States in 1848 (Treaty of Guadelupe Hidalgo) a lot of the Apache world had been at war with Spain and subsequently Mexico for almost 250 years. Central Arizona was an exception to this, being remote from the hegemony of Spain. The Dizhe'e raided regularly into Chihuahua and throughout Sonora to the Pacific coast, but in the safe haven of their home country (including Fossil Creek) they were geographically too remote and beyond the wrath of Spanish retribution.

The Yavapai groups along the north side of the Gila were familiar with the Spaniards, but contact was sporadic and unproductive, whereas their relatives to the north were virtually out of contact with any Europeans or Euro-Americans until the coming of the Mountain men and prospectors into the country north of the Gila and along the Hassayampa River after 1848. After 1848 no one was beyond the logistical and bureaucratic hand of the government in Washington. This fact gained momentum through the 1850's. Immigration from the east was filling up the open range in southern Arizona and because of that central Arizona became a refugium for all sorts of small, but desperate groups trying to avoid the final push of the conquest: Mohaves, Yumas, Southern Paiutes, Navajos, mixed groups of Chiricahua, Mescallero's and other Western Apaches, along with the local Dilzhe'e (Apache) and the various groups of the indigenous People we now call Yavapai. For the sake of modern clarification (or confusion) the government historically referred to virtually all of these ethnically diverse tribes and local bands as some type of 'Apache' regardless of their actual ethnicity.

For centuries prior to the disruption of the conquest, the Dilzhe'e and their Yavapai neighbors lived with a light hand and silent tread on the landscape, which has left an almost invisible physical signature, making it almost impossible to discern their passing within the archaeological record. And this, for better or for worse, is the case in Fossil Creek Canyon and vicinity.

Prior to the round up and forced march to San Carlos, the Dilzhe'e had been entrenched in Fossil Creek for centuries. Many important stories, songs and lessons recognized within western Apache culture emanate from Fossil Creek. And, although we know lower Fossil Creek was used by neighboring bands of Yavapai from across the Verde as a resource zone, there is no one living who can tell us anything definite about it by way of legends or lessons or songs. The ethnographic material as it stands is unreliable and in some cases simply false. It is their ghost.

The Dilzhe'e on the other hand lived throughout the length of the Fossil Creek Canyon for centuries and they call it Tu Do Tliz, which simply means the Blue Water Place. As is mentioned in another section of this report, families descending from numerous Western Apache clans called it home seasonally and throughout the year. Fossil Creek was a Dilzhe'e paradise. Water is abundantly available for small garden plots and it also attracted and harbored populations of game. Neither the Apache (nor the Yavapai) ate fish so that resource was not exploited. There was however lots of game in the uplands and the surrounding countryside and canyons were a cornucopia of useful stone, minerals, plant foods and essential medicines. Materials used in weaving beautiful watertight baskets and the construction of, cradleboards, domestic structures (kowas/gowas) and other personal items were plentiful.

When the remaining Dilzhe'e and surviving Yavapai's were unilaterally removed from the Rio Verde Reserve and forced to San Carlos in the late winter of 1875, several Apache families stayed behind and hid out in Fossil Creek living quietly and invisibly in that old sanctuary until their relatives returned a generation later around 1900. By then of course everything had changed and instead of living the old lifestyle the men went to work around the state on numerous public construction projects such as Roosevelt Dam, Cherry Creek Road and, as would be expected, the Fossil Creek hydro-electric facility.

Today we know from numerous trips with Tribal elders into Fossil Creek the locations of dozens of Apache places, from garden plots and home sites to card playing spots and the places where stories such as Frog Boy and Where People Walked Off of the Rocks into the Clouds originated. We know where the Smith children were placed on the roof of the summer ramada, while the family dogs fought off a mountain lion all night. There is barely a trace remaining on the surface marking the passing of these events as 'archaeological evidence', yet it all took place just the same.

Even when Apache (and for that matter Yavapai) camps are occasionally located they are often construed or recorded as 'archaic' or 'lithic scatters', or 'concentration of fire cracked rock'. Most (but not all) western Apache material culture that is diagnostic is perishable, being made from bone, wood, sinew, buckskin, rawhide, hair or plant fibers.

The half-life of anyone of these items on the surface is negligible compared to a Sinagua room block, Anasazi granary or pot cache. The clues left by these People are often as subtle as compacted ground and some replacement vegetation and that is the bulk of their physical legacy within Fossil Creek country. The trails still criss-cross the landscape, many of the plants and animals remain, but precious little if anything exists that is truly Dizhe'e or from earlier incursion by Yavapai families. And curiously to Anglo culture, that is the way the Old Apaches wanted it. They respected the rhythms and nuance of the natural world to the point of utilizing it only to the extent they could survive (quite successfully) within it, without altering it. It is the ultimate compliment of a successful culture to its source of sustenance and a reflection on their world-class stewardship. The decommissioning is a tribute to that noninvasive lifestyle, which can be a lesson to us all.

Recreation

Matthew F. Jedra and Martha E. Lee

Introduction

Information on current recreation conditions at Fossil Creek comes primarily from a 2002 report by Christa Roughan from the Red Rock Ranger District of the Coconino National Forest. This report reflects the most current data available on Fossil Creek recreation opportunities, activities, and resource conditions. Preliminary data collected from the visitor survey distributed from August 2004 through December 2004 is also included to supplement and update Forest Service information.

This section is divided into three components: current trends in recreation opportunities, use, and impacts; monitoring; and indicators. The information compiled in this report will provide baseline data for future management of recreation at Fossil Creek.

Current Trends

Recreation Opportunities

Figure 14 presents the Recreation Opportunity Spectrum (ROS) map of Fossil Creek. This map is based on the 1992 Coconino National Forest's most current ROS inventory of recreation opportunities on the forest. The ROS inventory for the Tonto National Forest – managed portion of the Fossil Creek area will be added at a later date. In addition to the ROS, natural springs and streams of the Fossil Creek are added to the map. Fossil Creek appears in red on the ROS map.

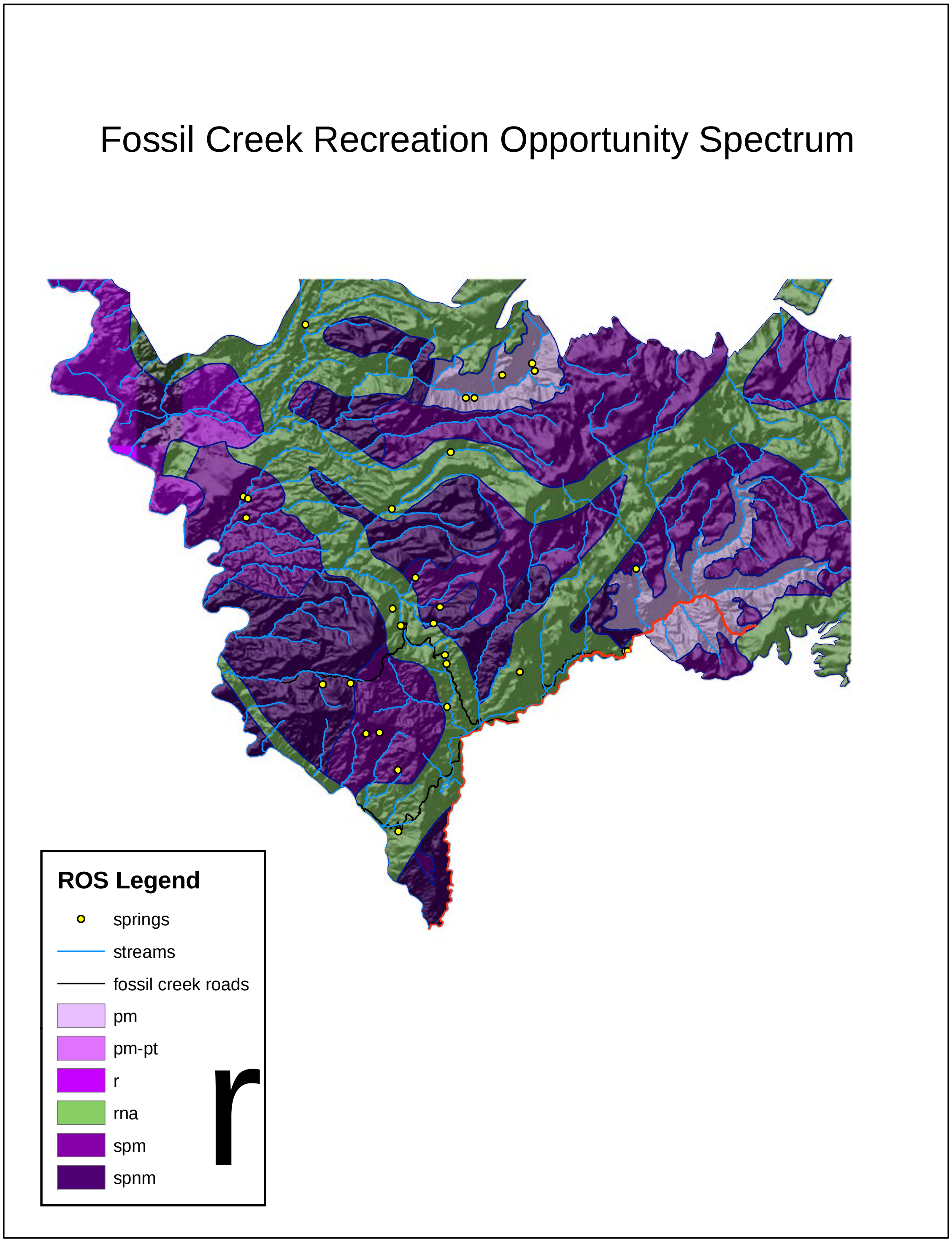


Figure 14. Recreation Opportunity Spectrum (ROS) inventory for the Fossil Creek recreation area (U.S. Forest Service 1992). The ROS classes are defined as; pm = primitive, pm-pt = primitive transition, r = roaded, rna = roaded natural area, spnm = semi-primitve non- motorized, and spm = semi-primitive motorized opportunities.

The recreation opportunities discussed in this section are major activities experienced by visitors to Fossil Creek in 2002. The opportunities mentioned here are a few of the activities that visitors take part in, but are not limited to. Information presented here comes from a 2002 Fossil Creek Watershed Analysis report prepared by the Red Rock Ranger District of the U.S. Forest Service (Roughan 2002).

a. Camping:

Camping is an important form of recreation at Fossil Creek. Majority of the campsites are dispersed, undeveloped, sites near popular swimming holes. These sites occur primarily along Forest Roads 708 and 502. Partying is also a known form of recreation at Fossil Creek. Roughan (2002) found a strong correlation among party locations and dispersed campsites along Fossil Creek.

The proximity of the communities of Pine, Strawberry, and Payson influence the condition of dispersed campsites. Sites closer to Pine and Strawberry on Forest Road 708 on the Tonto National Forest experience more use causing a greater amount of vegetation damage, and increasing the amount of denuded area at each site (Roughan 2002).

b. Swimming:

Water based activities such as swimming and fishing are common among visitors to Fossil Creek. Visitors participate in these activities at numerous locations along Fossil Creek. The majority of the swimming use takes place at the Forest Road 708 bridge. This area has limited parking which results in traffic congestion along Forest Road 708, especially during hot summer months and holidays (Roughan 2002).

c. Wilderness:

Located within the Fossil Creek area is a U.S. Congressionally designated Wilderness called Fossil Springs Wilderness on the Coconino National Forest in Arizona. The Fossil Springs Wilderness was designated in 1984 and includes 10,433 acres. Near the confluence of the Verde River and Fossil Creek is the Mazatzal Wilderness, located on the Tonto National Forest in Arizona. The Mazatzal Wilderness was designated in 1940 and expanded in 1984 and includes 252,500 acres.

d. Trail System:

The trail system within the Fossil Creek area provides hiking and backpacking opportunities into the Fossil Springs Wilderness and the Fossil Springs Botanical Area. Two designated trails are present in the Fossil Creek area, the Flume-Irving Trail (#154) and the Fossil Springs Trail (#18). Both are approximately 4 miles long. The Fossil Springs trail receives a significant amount of use compared to the Flume-Irving Trail due to the easier access to the trailhead (Roughan 2002).The Fossil Springs Trail drops approximately 1,500 ft in 4 miles and is a moderate to difficult hike. The Flume-Irving trail is roughly the same distance and has very little elevation change, less than 500 feet. The Flume-Irving trail is part of Forest Road 154 and provides access to Fossil Springs Wilderness. Forest Road 154/Flume-Irving Trail has three bridges and is primarily used by Arizona Power Company (APS), NAU researchers, and the U.S. Forest Service. APS currently maintains this road.

Throughout the Fossil Creek area there are a number of dispersed social trails throughout the Fossil Creek area that provide access to the creek at various locations. These dispersed trails are within close proximity to Forest Roads 708, 502, and 154 and dispersed campsites. *Social trails are user created trails created by continuous use. Social pathways result from short-cutting or from poorly marked trails or inadequate official trails.*

Recreation Use

a. Trail Use:

Trail registry data was gathered by the USFS Red Rock Ranger District from 1998-2003 at both Fossil Creek trailheads using trail registers located at each trailhead. The National Park Service Standard Trail Adjustment Factor was used to calculate more accurate trail usage (Roughan 2002). This expansion factor adjusts trail registration information to more accurately record the number of users a trail receives when a trail counter is not available. For example, for every trail user who registers, 2.5 people do not. When a trail counter is used, there is no need to use the NPS Standard Trail Adjustment Factor.

Flume-Irving Trail use ranged from 1,604 to 3,068 users between 1998 and 2003 (Table 21). The Fossil Springs Trail usage ranged from 5,922 to 26,651 users during the same time period (Roughan 2002). The Coconino National Forest was closed from June 2002 to July 2002 due to fire closures, thus lowering the number of users to the Flume-Irving and Fossil Springs Trails.

- Flume-Irving Trail #154: The Flume-Irving Trail had peak use by hikers and backpackers in the months of June, July, and September with an average group size of 1 to 2 people. The average annual recreation use was 2,446 visitors (Roughan 2002).

- Fossil Springs Trail #18: The Fossil Springs trail had peak use by hikers in the months of July, August, and September. The backpacker's peak use occurred in the months of April, July, and September, and the average group of visitors ranged from 4 to 8 people. The average annual recreation use was 15,568 visitors (Roughan 2002).

Table 21. Number of trail registrants from 1998-2003 for Fossil Springs and Flume-Irving Trail, Fossil Creek, Arizona.

Trail Name	Year	Day Use Hikers	Overnight Backpackers	Total	NPS Adjustment Factor	Number of Registrants after Adjustment Factor
Flume-Irving	2003	503	299	802	3.4	2719
Flume-Irving	2002	478	331	809	3.4	2743
Flume-Irving	2001	513	392	905	3.4	3068
Flume-Irving	2000	608	139	747	*2.2	1643
Flume-Irving	1999	505	224	729	*2.2	1604
Flume-Irving	1998	739	579	1318	*2.2	2900
Fossil Springs	2004	5655	3277	8932	*2.2	19,650
Fossil Springs	2003	2708	1279	3987	5.8	23,125
Fossil Springs	2002	2858	917	3775	5.8	21,895
Fossil Springs	2001	3227	1368	4595	5.8	26,651
Fossil Springs	2000	2315	377	2692	*2.2	5922
Fossil Springs	1999	2279	998	3277	*2.2	7209
Fossil Springs	1998	2474	1438	3912	*2.2	8606
Total		**24,349**	**11,319**	**35,678**		**125,016**

*National Park Service (NPS) Standard Trail Adjustment Factor. In the NPS Adjustment Factor column, please note that when it is a different number than 2.2, we had a trail counter placed at the trail to help record more accurate trail usage. For example, when the number is 5.8, for every 1 person who registers, 5.8 trail users do not.

b. Visitor Surveys

i. Childs Campground and Stehr Lake 2001 Visitor Survey

The Forest Service conducted a recreation user survey from July 2001 to October 2001 at the Child's Campground and Stehr Lake. Surveys were distributed randomly during the week and weekend. A total of 75 surveys were obtained during this time period (Roughan 2002) (see Appendix C for a copy of the survey questionnaire and a complete summary of survey results).

Results showed that day use on Monday through Friday was predominately visitors from the surrounding communities of Strawberry, Pine, and Camp Verde (Roughan 2002). Saturday and Sunday attracted more visitors from Phoenix, Flagstaff, and other surrounding communities. The most popular recreation activities at Stehr Lake and Child's Campground were camping, swimming, day hiking, and wildlife/nature viewing.

Eighty-eight percent of the visitors lived in Arizona, and 12 percent were from another state (Roughan 2002). Among fifty-five percent of Arizona visitors were from the Verde Valley or Pine/Strawberry areas and thirty-three percent were from other areas in Arizona (Roughan 2002). The majority of the visitors were in the 18-25 year old age group, thirty-six percent; followed by the 40-55 year old age group, twenty-seven percent, and then the 26-39 year old age group twenty-four percent (Roughan 2002). A majority of visitors stayed for two days, visited once a month, and visited the Verde Hot Springs numerous times.

ii. Fossil Creek 2004 Visitor Survey – Preliminary results

Northern Arizona University, School of Forestry began a recreation user survey in August 2004. The purpose of the survey was to obtain current information on Fossil Creek visitor demographics, preferred communication strategies, responses to proposed management strategies, recreation activities, and reasons for coming (see Appendix C for a copy of the survey questionnaire). Surveys are distributed to weekend visitors on-site at locations between Fossil Springs and Stehr Lake. As of early November 2004 approximately 258 surveys have been handed out, with 118 returned and analyzed. The survey will continue through December 2004 and begin again in Spring 2005. Highlights of the August – November 2004 survey results are included here. See Appendix C for a more complete summary of the preliminary results.

Fifty-two percent of Fossil Creek use occurs between the Irving Power Plant and the Fossil Springs Diversion Dam area. Forty-two percent of visitors stay for more than one day and 62 percent of visitors are returning visitors to Fossil Creek. Seventy-one percent of visitors access Fossil Creek from the town of Strawberry via Forest Road 708. Ninety-eight percent of the visitors are from Arizona and come with family and/or friends.

Most important reasons for visiting Fossil Creek include to view the scenery, to enjoy the sounds and smells of nature, to see Fossil Creek, to get away from life's demands, to be with family or friends, to experience tranquility, and to relieve stress and tension. The most popular recreation activities at Fossil Creek include sightseeing, walking, swimming, wading in Fossil Creek, and day hiking.

Forty-five percent of visitors support the removal of non-native fish, sixteen percent do not support the removal of non-native fish, and thirty-nine percent do not feel strongly one way or the other. Fifty-five percent of visitors support the removal of the Fossil Springs Diversion Dam to restore full flows, 30 percent do not support the removal of the dam, and 16 percent do not feel strongly one way or the other.

Recreation Impacts

In 2002 the Forest Service conducted a dispersed campsite impact inventory throughout the summer and into the fall at Fossil Creek. This research was conducted along Forest Roads 708, 708A, 500, 9D, 502, 9206W, 502A, and 154 along with the Fossil Springs Wilderness. A total of 211 campsites were inventoried (Roughan 2002):

107 campsites Forest Road 708 and 708A
6 campsites along Forest Road 500
2 campsites along Forest Road 9D
52 campsites along Forest Road 502
11 campsites along Forest Road 502 A

2 campsites along Forest Road 9206W
29 campsites in the Fossil Springs Wilderness
2 campsites below the Fossil Springs Diversion Dam

Each of the 211 campsites in the Fossil Creek area were evaluated as to the amount of impact to the surrounding environment. Each campsite was assigned a value based on the level of environmental impact. The campsites were rated as a 1 (low impact), 2 (moderate impact), and 3 (high impact). This rating was used to evaluate all 211 campsites based on eleven indicators: vehicle access, camp location, loss of ground vegetation, developments, site cleanliness, isolation, distance from Forest Road, tree damage, amount of root exposure, and the amount of toilet paper and human feces (Roughan 2002). Other information collected at each campsite included size of camp area and total denuded area, measured in square feet. In addition to, photo points, Global Position System (GPS) locations, compass bearings and a rough sketch of each site (Roughan 2002). Each campsite was individually tagged and given an identification number.

To analyze the results, a point system was assigned to each of the indicators, ranging 10-16 (low impact), 17-23 (moderate impact) to 24-30 (high impact) campsites (Roughan 2002). Based on the data collected from all 211 dispersed campsites, 85 were rated as low impact, 120 were rated as moderately impacted, and 6 were highly impacted.

The highest indicators measured on the 211 campsites were vegetation loss and the amount of toilet paper present at each campsite. The largest campsite has 12,080 square feet of denuded area. This site is located within riparian vegetation on Forest Road 708 in Hackberry Canyon. The second largest campsite is also located in riparian vegetation near Sycamore Spring. This campsite had 11,070 square feet of denuded area. The total amount of denuded area caused by dispersed camping in Fossil Creek in 2002 was approximately 8 acres or 347,785 square feet (Roughan 2002).

Monitoring

The recreation monitoring program at Fossil Creek is a collaborative effort between recreation managers on the Red Rocks Ranger District of the U.S. Forest Service (FS), and Northern Arizona University (NAU). The program is designed to build on existing Forest Service data about Fossil Creek visitors and visitor use. The program includes three information gathering and monitoring projects:

(1) a 20 question visitor survey gathering information on Fossil Creek visitors such as preferred information communication strategies, responses to proposed recreation management strategies, recreation activities, reasons for visiting Fossil Creek, and environmental stewardship (preliminary results presented above);

(2) a campsite impact and monitoring effort initiated by the Forest Service in 2002 (and described above) wherein campsites and other high use areas are mapped and permanent resource condition monitoring plots established; and

(3), a literature review focusing on identifying strategies for successfully implementing a Fossil Creek recreation monitoring and management plan including recommendations for education, engineering, and enforcement strategies based on a review of published literature and land management agency documents.

We will collaborate with the Forest Service and other Pulliam research partners on an information and education campaign designed to disseminate information about on-going Fossil Creek research and management within the Fossil Creek area and at planned public participatory meetings.

Indicators

Indicators useful for assessing change in recreation use conditions that will be measured as part of the on-going monitoring effort include: 1) the amount and type of recreation impacts occurring; 2) the number and distribution of Fossil Creek visitors, as measured by U.S. Forest Service trail registers; 3) visitor perceptions of Fossil Creek recreation experiences (types and extent of problems encountered, for example); and 4) visitor perceptions of Fossil Creek management decisions (changes in level of support, for example).

Grazing in the Fossil Creek Watershed

Compiled by Michele James

The following information is a summary of the existing grazing allotments with the Fossil Creek Watershed. Within the Coconino National Forest, four allotments are located partially within the 5th code watershed, and the information in this section, except where noted, is summarized from a September 30, 2002 U.S. Fish and Wildlife Service biological opinion (USFWS 2002a). Within the Tonto National Forest, three allotments are present within the 5th code watershed. Summaries of the Tonto allotments are from Christine Thiel, Supervisory Range Management Specialist, Payson and Pleasant Valley Ranger District, Tonto National Forest (electronic communication dated March 14, 2005).

Table 22 summarizes available information for each allotment.

Table 22. Acres, permitted use, type of grazing system, vegetation type, range condition and trend, and soil condition of grazing allotments in the Fossil Creek watershed.

Allotment:	13-Mile	Hackberry/ Pivot Rock	Fossil Creek	Deadman Mesa*	Cedar Bench	Hardscrabble**	Ike's Backbone***
Acres (Total/Capable):	31191/18996	80314/N/a	38482/N/a	32347/15388	32198/21160	20845/N/a	46271/N/a
Permitted use:	N/a cow/calf yearlong	760 head yearlong	477 cattle year long, 8 cattle & 5 horses temporary	150 adult cattle, winter use: 10/21-5/31	500 cattle, winter use: 11/1-5/31	140 adult cattle yearlong	280 cattle
Grazing system:	24 pastures year round, 40% utilization	51 pastures year round, 50% utilization	18 pastures year round, 60-70% utilization	8 pastures, rest rotation/deferred, <50% utilization on uplands	7 pastures, 30-40% key forage species in uplands	7 pastures yearlong, 30-40% utilization on key forage species in uplands	19 pastures
Vegetation type:	N/a	N/a	N/a	Pinyon-juniper woodland	Grasslands, Pinyon/juniper, ponderosa pine, riparian	N/a	N/a
Range condition & trend:	81% poor, 19% fair Stable to upward	42% poor, 13% fair, <1% very poor Stable to upward	Summer portion: 78% good to fair with upward trend, winter portion: N/a.	N/a	12% fair, 62% poor, 25% very poor	14% good, 29% fair, 43% poor, 14% very poor	N/a
Soil condition:	N/a	N/a	N/a	41% satisfactory	33% fair 67% poor	14% good, 72% fair, 14% poor	N/a

* Allotment in non-use status, and vacant with not current permittee.
** Allotment currently in non-use status.
*** Allotment combined with Skeleton Ridege Allotment; numbers presented are for both allotments.
N/A = Data not available.

Coconino National Forest

Allotments that fall partially within the Fossil Creek 5th code watershed on the Coconino National Forest include: Thirteen-mile Rock, Hackberry Pivot Rock (two allotments, treated as one), Fossil Creek, and Ike's Backbone (managed by the Tonto National Forest in combination with the Skeleton Ridge Allotment). Below is a brief summary of existing conditions as presented by the Forest Service for these four allotments.

Thirteen-mile Rock Allotment

This grazing Allotment Management Plan (AMP) and permit is in effect through December 21, 2010. It is 31,191 acres in size and falls within the following 5th code watersheds: Fossil Creek, Horseshoe Reservoir and West Clear Creek. The type of grazing system is described as: year-round on allotment in three zones (winter, transition, summer); 24 pastures; winter pastures grazed with intensive deferred rotation; summer and transition pastures grazed with singe herd, intensive rest-half/graze-half management strategy on alternative years; 40% utilization. The range condition and trend of the Allotment was described in 1999 as follows: 15,384 acres poor condition and 3,612 acres fair condition; 71% of Parker three-step clusters have fair to poor range condition. The Forest Service indicates that this allotment is in a stable to upward trend.

The AMP includes a plant phenology-based grazing strategy, a pattern of grazing use and permitted livestock numbers, and maintenance of existing range structures. Additionally, the AMP includes the addition of new range structures, soil and vegetation improvements, pinyon-juniper grassland maintenance, browse species maintenance and improvement, riparian vegetation monitoring and potential restoration at Cottonwood Spring, and general allotment monitoring. The AMP is described more specifically below:

• Maximum forage utilization levels would not exceed 40 percent average use within each pasture. This utilization level includes use by wildlife (e.g., elk). Livestock would be moved to the next pasture scheduled for grazing if the grazing use approaches 40 percent. Where livestock have access to West Clear Creek during the winter dormant period, a 20 percent or less utilization of woody species would be allowed if all three age classes of riparian vegetation are present. Only five percent use is allowed in riparian areas if the middle age class is absent.

• Livestock use would continue to be managed under the current plant phenology-based strategy with the graze-half/rest-half pattern in the high- and mid-elevation pastures and annual use in the low-elevation pastures. Pastures would be grazed for 20 days or less during the growing season and up to 60 days during the dormant season. The approximate duration of grazing for each pasture is planned during development of the annual operating plan (AOP) based on anticipated plant growth and resource needs; the actual duration of grazing could vary from the AOP schedule, depending on the actual plant growth stage encountered in each pasture.

• Wildlife breeding areas and key wintering habitat needs, soil conditions, and vegetative groundcover (plants and litter) would be specifically considered when planning annual livestock grazing use. During drought years, livestock would not be allowed to use pastures scheduled for rest that year.

• The Winter Unit would continue to be grazed for 60 days during the dormant season (January through February) each year until the proposed pasture-division fence is installed. When the division fence is complete, the grazing period would be reduced to approximately 30 days in each pasture during the dormant season. Existing livestock trails would be used to move livestock to the less steep country for grazing when livestock are moved into the Winter West Pasture in February.

• Livestock would be moved through the Winter West and Winter East Pastures during June within a maximum of 10 days using existing livestock trails. Livestock would be driven through the pasture and would not be allowed access to West Clear Creek.

• Livestock would be grazed in the Heifer Pasture for approximately 20 days in March. The two restricted access points to West Clear Creek would be used as the water sources for the herd during this grazing period. The herd would then be moved to the Wingfield Mesa group of five pastures.

• During June, livestock would be driven through the Heifer Pasture toward the summer grazing pastures over a maximum of five days. The main herd would move through the pasture in one to two days. The gates to the two restricted livestock access points on West Clear Creek would be closed during that time. If newborn calves cannot move through the pasture with the herd within the anticipated one to two-day move, the calves and their mothers would be allowed to stay for an additional two to three days while the remainder of the herd is moved through the Winter Unit(s). The gates to the water lanes would be opened while the calves and their mothers are allowed to stay in the Heifer Pasture. The calves and their mothers would be moved out of the Heifer Pasture to rejoin the main herd within three days.

• The Toms/Good Enough Pasture would be grazed every other year when the northern tier of pastures is being grazed to synchronize the graze-half/rest-half strategy with the four allotments to the north of the Thirteen-mile Rock Allotment.
• The Bob’s and Cactus Pastures would not be grazed.

• Three of the four Wingfield Mesa pastures would be grazed under a rest-rotation strategy for 100 days each spring, with the sequence of use and rest altered each year among the pastures. The growth rate of cool season grasses would be monitored to determine the allowed length of the gazing period in each pasture.

Hackberry Pivot Rock Allotment

The AMP for these two allotments (Hackberry and Pivot Rock) expires on December 31, 2006. The allotments are 80,314 acres in size and 760 head of cattle are permitted. Fifth code watersheds in which these allotments fall partially or wholly include Fossil Creek, West Clear Creek, and Horseshoe Reservoir. The type of grazing system is described as: year-round on allotment in three zones (winter, transition, summer); 51 pastures; intensive rotation system with use based on plant phenological growth criteria; 50% utilization. The range condition and trend of these allotments is described as follows: Pivot Rock: (1962 to1983) 42% poor, 13% fair, <1% very poor; remainder rates as non-range and is closed to grazing; (1983) stable or upward trend in most transects; Hackberry: (1964 and 1967) majority of acres in poor and very poor condition; no range transect data to determine trend.

This allotment ranges in elevation from 2,800 feet along the Verde River to over 7,600 feet along the Mogollon Rim. Livestock are managed under the principles of Holistic Resource Management, with livestock movement, control, and use directly tied to plant growth. As an annual iteration of the AMP, the Annual Operating Instructions (AOI) specify pasture use and livestock numbers during a specific year. The AMP implements objectives for the allotment, which include improved watershed conditions through greater control of the livestock. The AMP, and thus the AOI, incorporate pasture rest from livestock grazing on an annual basis during the growing season in the winter/spring pastures, and within specified pastures in the summer/fall use areas. The allotment is grazed as separate seasonal zones – the winter/spring area pastures (Sonoran desert scrub/ pinyon-juniper) and the summer/fall area pastures (ponderosa pine). The AMP/AOI specify grazing all the winter/spring pastures (Hackberry portion of the allotment) from late October to late May. The summer/fall pastures (Pivot Rock portion of the allotment) are grazed from late May through late October. This grazing strategy, specified in the 2001 AOI, results in:

- complete rest from livestock grazing on three pastures in the summer/fall use areas (Baker, Huffer, and Potato);
- complete growing season rest or deferral in the winter/spring use area;
- pastures are grazed for short time periods (2 to 37 days), and most pastures are grazed once during the year, except when a lack of other access forces use of a previously grazed pasture as a pass-through to another pasture;
- growing season deferment on those summer/fall use pastures which are grazed by livestock during September and October.

Livestock management is tied directly to plant growth. When plants are in the dormant stage, grazing periods can be for as long as 2 months. During fast growth, most grazing periods are generally 20 days or less. These grazing periods reduce and/or eliminate the chance of overgrazing by domestic livestock.

In addition to the phenology-based management, in areas where there are two grazing ungulates in competition (cattle and elk), some pastures in the summer/fall area (Pivot

Rock Management Unit) are rested every other year, while others are deferred through the growing season every year. This allows for livestock and rest to be used as tools to help manipulate elk grazing patterns. That is, elk move into areas grazed by livestock once plant regrowth starts attaining the highest plane of nutrition from the new plant growth. At the same time, the rested pastures contain enough old feed to discourage elk from grazing on the new plant growth in those pastures. Fencing and topographic features prevent livestock from accessing the Verde River, which flows on the west side adjacent to the Hackberry management unit and is the allotment boundary. As a result of the fence construction along the Verde River, the allotment's permitted livestock are excluded from access to the Verde River, except for an emergency access for water. However, the steep slopes on the allotment prevent an even distribution of grazing throughout individual pastures, resulting in disproportionate use of riparian areas and riparian pastures.

A short segment (1/4 mile) of fence was constructed in the Potato Pasture in 1999 that, with the exclosure constructed in 1997 and the existing watershed exclosure in Potato Draw, splits this Pasture into the North and South Potato pastures. This will simplify management and increase flexibility in the Pivot Rock Management Unit. A livestock exclosure was constructed around Potato Lake in 2000, tying in to the fence discussed above, and totally excluding livestock from Potato Lake. A livestock exclosure was constructed in the Potato pasture in 1997, which excludes livestock grazing in the headwaters of East Clear Creek. In addition, short sections of drift fence were constructed in 1997 in the Kehl and Clear Creek pastures, downstream from the Potato Pastures, which will prevent cattle access to East Clear Creek. A mile of fence separates the Kehl and Clear Creek pastures. This fence crosses East Clear Creek near the junction of Poverty Draw and East Clear Creek. Due to past improvements, cattle can now cross East Clear Creek in only one location.

Fossil Creek Allotment

Extending above and below the Mogollon Rim, the Fossil Creek Allotment is 15 miles across from west to east. The Allotment's southern boundary is Fossil Creek proper, with the southern pastures extending to the banks of the Verde River. Elevations on the allotment range from 2,800 feet at the Verde River to 6,200 feet at the northeast corner near Salomon Lake. The Allotment is 38,482 acres in size. The permit for this allotment expires on December 31, 2005. Permitted use is 477 cattle and 8 cattle and 5 horses under a temporary permit. Fifth code watersheds include Fossil Creek, Horseshoe Reservoir and West Clear Creek. The type of grazing system is described as: year-round on allotment in three zones (winter, transition, summer); 18 pastures; intensive rotation system with use based on plant phenological growth criteria; 60-70% utilization. Range condition and trend were described in 1999 as follows: summer portion of allotment showed 78% of vegetation in good to fair conditions with upward trends. No data are available on winter range.

The Fossil Creek Allotment's vegetation follows traditional elevation regimes, with ponderosa pine stringers in the high elevations to grasslands and desert scrub at the low elevations. The allotment has three distinct management zones: the Winter Use Zone in the Verde Valley (2,800- 5,000 foot elevation); the Transition Use Zone in the pinyon/juniper woodlands (5,000-5,900 foot elevation) and the Summer Use Zone in the ponderosa pine (5,900-6,200-foot elevation). The allotment contains an estimated 340 acres of riparian habitat along several streamcourses.

The allotment's livestock are managed under the principles of Holistic Resource Management, with livestock movement, control, and use tied directly to plant growth. All pastures are grazed each year, with deferred rest. Pastures within the summer and winter ranges are rotated each year where each pasture is used at a different time of season when possible. This intensive management program, with its short-duration grazing periods, eliminates overgrazing and reduces the potential re-grazing of forage plants before full plant recovery occurs.

During the winter months of plant dormancy, the main herd grazes for approximately 35-40 days. There are 15-20-day grazing periods during active plant growth periods of the spring and summer months. Exceptions to these grazing periods do occur, particularly when dealing with small numbers of bulls and/or heifers during dormant growth periods (winter months), where g razing periods may extend from 60 to 90 days.

Livestock grazing occurs within riparian habitats during the dormant growing season within the Stehr Lake Pasture on a three-quarter mile portion of Fossil Creek and on the northeast side of Stehr Lake. To protect riparian habitat, sensitive stream conditions, and threatened, endangered, and sensitive species associated with the riparian area, grazing in the Stehr Lake Pasture occurs for only 15 days during January/February dormant growth periods. For the first time since the 15-day restriction has been imposed, cattle will rotate from Surge Tank to Boulder Pasture, trailing back through Stehr Lake Pasture. This trailing through Stehr Pasture is anticipated to occur over a 3- to 5-day period, with the majority of the herd moving within 1-2 days and the remnant numbers trailing over the next 2-3 days.

Following the 1998 Ongoing Grazing Consultation mitigation requirements, a Forest interdisciplinary team (including grazing permittee representatives) made an on-site evaluation of livestock access to Fossil Creek. The team found four access points for livestock entry to the creek. Two of the four access sites were fenced in December 1999 to protect the riparian habitat.

<u>Ike's Backbone and Skeleton Ridge Allotments</u>

These allotments are managed together by the Tonto National Forest, although the Ike's Backbone Allotment is located on the Coconino National Forest (pers. comm. Jerry Stefferud). The following limited information on the Ike's Backbone and Skeleton Ridge Allotments is from the Verde Wild and Scenic River Comprehensive Management Plan Final Environmental Assessment (June 2004).

The grazing permit for Ike's Backbone Allotment is held by the Skeleton Ridge Allotment permittee and the two allotments are managed together. The allotments are

46,271 acres in size and contain 19 pastures. Permitted livestock numbers total 280. Four pastures and a holding pasture allow livestock to access the Verde River in the winter and spring on the Skeleton Ridge Allotment. One pasture on the Ike's Backbone Allotment previously allowed livestock Verde River access, but is now fenced. About 20 cattle annually cross the Verde River from the Skeleton Ridge Allotment to graze Ike's Backbone in April and return to Skeleton Ridge in September.

Tonto National Forest

Allotments that fall partially within the Fossil Creek 5th code watershed on the Tonto National Forest include: Deadman Mesa, Cedar Bench, and Hardscrabble. Below is a brief summary of existing conditions as presented by the Forest Service for these three allotments.

Deadman Mesa Allotment

This allotment is 32,347 acres in size, of which 15,388 acres are considered capable (USFWS 2002b). The major vegetation type is pinyon-juniper woodland. The allotment has been vacant (in non-use status) since 2000 according to a Non-use Agreement for 183 AUMs. This Non-use Agreement will be resolved once the area has returned to a normal precipitation pattern (USFWS 2002b). The allotment is considered vacant with no current permittee.

This is a winter allotment with a term permit of 150 adult cattle, from October 21 – May 31. It is managed as a rest rotation/deferred system and contains eight allotments. The AMP for this allotment was approved on February 26, 1988.

Utilization limits are determined to be (USFWS 2002b):

Streambank – <20% of alterable banks;
Herbaceous – riparian, limit use to <30% plant biomass;
Woody – riparian, limit use to <50% of leaders on plants <4.5 feet tall; and
Uplands – limit use to <50%

The condition of the soils within the allotment is rated as overall unsatisfactory (41% satisfactory) and the riparian condition is rated as satisfactory (USFWS 2002b).

Cedar Bench Allotment

Cedar Bench is an active allotment with a term permit (winter season) of 500 permitted cattle between November 1 and May 31. The AMP for this allotment was approved on December 5, 1986. This allotment is 32,198 acres in size and includes the following vegetation types: grasslands (4,607 acres), pinyon-juniper (20,621 acres), ponderosa pine

(6,540 acres), and riparian (430 acres). There are seven main pastures within this allotment.

Utilization standards are set at: 30-40% on key forage species in the uplands; 50% of current year's growth on browse; 30% on riparian herbaceous species biomass, 50% of leaders browsed on the top 1/3 of woody species; and, streambank alteration is limited to less than 20% of alterable banks.

Range condition as measured in 1982/1985 is reported as:

Fair Condition – 2,574 acres (33% of allotment vegetation and soils visually estimated to be in fair condition);
Poor Condition – 13,204 acres (67% of allotment vegetation and soils reported visually to be in poor condition);
Very Poor Condition – 5,382 acres (visual estimates indicate that no key areas remain in very poor condition).

Since the 2002/2003 season, the Forest Service reports that this allotment was grazed by 65 adult cattle.

<u>Hardscrabble Allotment</u>

Harscrabble is an active allotment with a term permit (140 adult cattle yearlong). It is 20,845 acres in size. This allotment is currently in non-use. It was de-stocked in late spring 2002 due to the drought and has not been restocked with cattle since. In addition, in 1986, a non-use agreement was developed for resource improvement. This agreement reduced the allotment by 16%. This non-use agreement is still in effect. The allotment has three winter pastures and four summer pastures. Pastures are scheduled to be used per the approved AMP (approved August 20, 1986) for 1.5 to 4 months depending on season of use, size of pasture, and available forage.

Utilization standards are set at: uplands – herbaceous, 30-40% on key forage species; 50% on woody browse species of current year's growth; 30% on riparian herbaceous; woody riparian limited to 50% of leaders browsed on top 1/3 of plant less than 6 feet in height; streambank alteration is limited to less than 20% of alterable banks.

Range condition as measured in 1985 is reported as:

Good Condition – 2,918 acres vegetation condition (14%) and 2,918 acres soil condition (14%);
Fair Condition – 6,045 acres vegetation condition (29%) and 15,008 acres soil condition (72%);
Poor Condition – 8,963 acres vegetation condition (43%) and 2,918 acres soil condition (14%);
Very Poor Condition – 2,918 acres vegetation condition (14%) and zero acres soil condition.

What's Next?

Research and Monitoring at Fossil Creek

The primary purpose of the State of the Watershed Report is to provide information about Fossil Creek to those involved in and interested in the current and future management of this unique area of central Arizona. The Report summarizes baseline conditions that can be used to track changes to the environment over time. As such, this Report will need to be updated as information is gathered about changes in the physical, biological and social environment, now that full flows have been returned to Fossil Creek.

Baseline information has been collected from Fossil Creek watershed. Much of it is presented in this report or will be published in journals in the near future. However, continued research and monitoring of physical, biological, and social changes at Fossil Creek is imperative. Such research and monitoring will: allow for a greater understanding of the effects of restoration on the unique resources of Fossil Creek; will assist the U.S. Forest Service in their management of this area; and, will inform decision-making in similar restoration efforts elsewhere.

Below, we provide a summary of planned and desired research and monitoring as discussed in each section of the Report:

Physical and Biological Environment

Climate

- In 2002, lower amounts of precipitation occurred throughout the Fossil Creek watershed, resulting in lower than normal amounts of recharge. Although not measured, it is possible that lower amounts of recharge could eventually impact the flow at Fossil Springs. Stream flow rates below, but close to Fossil Springs should be monitored to determine the effect of drought, climate change, and/or groundwater development.

Soils

- Soil condition class ratings should be refined through on-site investigation to validate soil condition or rate soil condition on a large-scale (small acreage basis).
- The soil section offered the conclusion that the incremental impact of continued recreational use along Fossil Creek, especially along the middle reach, likely results in decreased streambank vegetation, increased sediment and peakflows as compared to natural conditions with satisfactory soils and well-vegetated streambanks. This recreational use, in combination with historic and current grazing strategies in the watershed contributes to soil degradation. The physical and biological conditions of the soil system are at risk or do not support additional disturbance. Therefore, monitoring of soil condition, streambank vegetation, stream sediment and peak flows in the short- and long-term is recommended.

Hydrology, Watershed and Channel Conditions, Water Rights

- As the climate changes or other changes to recharge or discharge to the aquifer occur either naturally or potentially by actions of humans (such as fire management, grazing, and the increasing utilization of wells within the "C-aquifer" system), it is important to understand how the geology is connected to the sustainability of Fossil Springs. Long-term monitoring is desirable, but is not presently the responsibility of any party or parties. Beginning in summer 2005, a NAU civil and environmental engineering Master's student will be identifying and evaluating suitable locations, technologies and strategies for both low-flow and high-flow stream gauging on Fossil Creek.
- The Fossil Springs Diversion Dam will be lowered at least 14 feet in 2007, releasing a significant portion of the nearly 25,000 cubic yards of sediment present stored behind the dam. This sediment movement will be accompanied by environmental and ecological impacts, both upstream and downstream of the dam. These impacts will be monitored and evaluated by NAU civil and environmental engineering researchers. Changes in sediment thickness will be monitored with a series of cross-sections and topographic surveys, both upstream and downstream of the Fossil Springs Diversion Dam. Pebble counts will be used to assess sediment grain-size distributions and their variability in space and time.

Spring Characterization and Groundwater

- The individual spring orifices (of which there are over 60) of Fossil Springs are being located and characterized as part of on-going studies by NAU. Once these are located, it will be possible to identify and track changes to their location or discharge through time.
- The goal of management for the springs of Fossil Creek is to sustain a baseflow of spring discharge necessary and sufficient to maintain the associated aquatic and riparian ecosystems, and the travertine processes. A request to maintain baseflow in Fossil Creek is part of the U.S. Forest Service instream flow assessment.
- As identified above, there is a critical need to establish a gauging station on Fossil Creek immediately downstream of the last spring orifice to monitor trends in the baseflow of Fossil Springs.
- Although comprehensive biological surveys have not been completed of the over 60 individual spring orifices, it is likely that specific microhabitats and specific species are dependent on each of the orifices in the spring complex.
- After characterization of the individual spring orifices in the Fossil Springs complex, NAU will build a three-dimensional hydrogeologic framework model for the aquifer which contributes flow to Fossil Springs. The framework model will serve as the base for future numerical groundwater flow models for Fossil Springs which can help understand how changes in management to the aquifer or the watershed may influence the quantity and quality of water discharging from the springs.

Water Quality

- In conjunction with the University of New Mexico, NAU is examining the geochemistry of travertine-depositing springs of the Arizona Transition Zone (which includes Fossil Springs).
- It is desirable to establish a baseline monitoring program to detect changes in the water chemistry of Fossil Springs. This monitoring will include major cation and anions to examine the change in carbonate chemistry and the potential for changes in travertine formation, as well as other important dissolved constituents.

Vegetation

Few monitoring recommendations are made in this section because it was felt that vegetation management fell under the purview of the U.S. Forest Service. However, it is clear that the following vegetative factors should be monitored in both the short- and long-term:

- Changes in riparian vegetation composition and width both above and below the Fossil Springs Diversion Dam after removal of the top 14 feet in 2007.
- Spread of exotic species/noxious weeds within the watershed and within the Fossil Creek drainage.

Aquatic Habitat and Fish

Fish

- There is a critical need for monitoring for non-native fish following the construction of the fish barrier at Fossil Creek and the completion of the native fish restoration project. This monitoring should determine if the barrier prevents upstream migration of non-native fish and assess whether non-native fish are being transplanted back into Fossil Creek by humans.
- Monitoring of the recovery of native fish in Fossil Creek should also occur. Such monitoring should address the density of both native and non-native fish using the same standardized methods used in pre-removal surveys.
- Research that will help interpret native fish responses in Fossil Creek include quantification of invertebrate assemblages (including crayfish) and food-base standing mass, experiments studying whether native chub are able to control non-native crayfish, and stable isotope studies to test if the trophic position of native fish increases once non-natives are removed.

Macroinvertebrates

- Monitoring invertebrates following restoration of full flows is an essential component of documenting food web and ecosystem recovery. Methods used to collect pre-treatment data should be used again and focus on the same sites, using pre-restoration data and sites above the diversion dam as controls. Future monitoring should focus on documenting changes in composition and distribution.
- Monitoring of the recovery of macroinvertebrates after impacts caused by the piscicide used in the native fish restoration project is also important.

- Comparison of invertebrate assemblages in newly formed travertine zones to the current, remnant travertine will assist in determining whether returning full flows helped promote native macroinvertebrate assemblages.
- Certain species should be specifically monitored and used as indicators. These include the endemic Fossil Springsnail and the Page Springs caddisfly. Specifically, monitoring should determine if flow restoration increase dispersal of these species and increase gene flow among populations.
- The exotic freshwater clam, *Corbicula fluminea*, known from the lower reaches of Fossil Creek, should be monitored to determine if it is actively moving upstream.

Leaf Litter Decomposition

- Monitoring should determine if the return of full flows to Fossil Creek results in higher overall leaf litter decomposition rates below the diversion dam.
- Monitoring should determine if higher rates of decomposition occur in relation to an expanded travertine zone after return of full flows.
- Monitoring should determine if leaf letter processing rates are lower than expected due to slower recovery of macroinvertebrate populations after piscicide (antimycin) treatment.
- After removal of the diversion dam in 2007, monitoring should determine if increased sediment loads cause a temporary reduction in leaf litter decomposition.

Crayfish

- Monitoring of crayfish should continue at the sites NAU has established. Mark and recapture protocols should be used over standard trapping as they provide a more accurate estimate of population size.

Terrestrial Species

Birds

- By 2010, complete two consecutive years of inventory of all potentially suitable habitat for listed and candidate bird species (including the yellow-billed cuckoo and common black hawk), using accepted protocols, within the upper, middle and lower reaches of Fossil Creek.
- A complete inventory of bird species in the Fossil Creek riparian area would provide valuable information about the bird communities and would assist in determining changes in the quality or quantity of habitat over time. Baseline inventory (prioritized by reach) should consist of point count surveys for breeding birds as well as incidental surveys during the breeding period, spring and fall migration, and wintering period. Surveys for nocturnal species should also be conducted.
- After completion of above inventories, a monitoring program should be developed to document bird community changes over the next five to ten years. In order to keep the costs to a minimum, the monitoring program could include sub-sampling of randomly selected points or habitats with a given reach or throughout the Fossil Creek riparian habitat.

- As funding for the above outlined monitoring and inventory is limited, grant funding opportunities should be pursued.

Mammals

- Yearly monitoring of the lower reaches of Fossil Creek for river otters should occur through at least 2010. Long-term monitoring for this species should continue in the lower reaches and extend to the middle and upper reaches depending upon on-going monitoring results.
- Monitoring of sensitive bat species including the western red bat, California leaf-nosed bat, spotted bat, Allen's big-eared bat, and Townsend's bit-eared bat should take place within the Fossil Creek watershed in the near future. Such monitoring should determine if these species are present and if other bat species are present. Such monitoring should consist of, at a minimum, use of the Anabat II to record bat sonar, identify species present, and identify roost sites, if possible.
- Determination of the presence of the Arizona grey squirrel in the riparian area of Fossil Creek is recommended.

Amphibians and Reptiles

- The distribution of lowland leopard frogs should be monitored prior to, during, and after the removal of the Fossil Springs Diversion Dam along the length of Fossil Creek.
- Monitoring of the persistence of the existing leopard frog population should take place throughout the decommissioning process.
- Complete the baseline inventory work for reptiles (Arizona toad, narrow-headed garter snake, and Mexican garter snake) in the Fossil Creek area. Some of this work has already been conducted, thus minimal time and expense is expected to complete this work.
- Reptile monitoring should determine if nursery habitat for the species is present, to what extent, and should determine if recreational use is impacting them.
- Because both the narrow-headed and Mexican garter snake populations are in decline throughout Arizona, monitoring for the presence of these species and the condition of habitat should be a priority.
- Bullfrog movement upstream into Fossil Creek should be monitored.

Invertebrates

- Monitoring of the Fossil Springsnail should be given a high priority because of the potential negative effects of recreational use. Monitoring should occur at regular intervals and should begin as soon as possible.
- A monitoring plan for the Fossil Springsnail should be developed by the end of 2006 or earlier.
- Presence/absence surveys should be conducted for sensitive invertebrates. Priority for determining presence/absence should be given to those invertebrates most at risk of potential negative effects related to restoration of Fossil Creek (namely recreational activity).

Humans and the Social Environment

Cultural and Archeological Resources

- A series of monitoring activities specific to the Fossil Creek area are outlined in the Report. These monitoring elements are designed to maintain or enhance archeological and historic site integrity. These elements are to be implemented by both the Coconino and Tonto National Forests, in addition to monitoring prescribed in the Forest Plans. However, the implementation such monitoring is based on the availability of funding.

Recreation

- Recreation monitoring will continue in the Fossil Creek area, including visitor surveys and campsite impact and monitoring.
- A recreation monitoring and management plan will be created to provide recommendations for education, engineering, and enforcement strategies within the Fossil Creek area.
- Gaining information on visitor perceptions of Fossil Creek recreation experiences and management decisions will be important indicators of how to manage future recreation at Fossil Creek.

Grazing

Grazing monitoring falls under the jurisdiction of the U.S. Forest Service. Allotments within the Fossil Creek watershed are located on both the Coconino and Tonto National Forests. In general, monitoring of these allotments include the following:

- Monitoring of site conditions will be ongoing.
- Impacts on soil and vegetation conditions will be used to assess the continuation of allotment use.
- Allotment use may be restricted when drought conditions persist to protect the site conditions.

Conclusion

Research and monitoring as summarized in this section and in the body of the State of the Watershed Report will assist in determining short- and long-term changes in the physical and biological conditions, as well as the sociological adjustments related to human use and recreation at Fossil Creek. The authors hope that both monitoring and research will remain a priority for all involved institutions, organizations, governments, and agencies.

As has been demonstrated through the Fossil Creek native fish restoration project, a multi-agency/organization partnership offers a valuable tool that facilitates the monitoring and research necessary to evaluate the success of and future needs and applications in watercourse and watershed rehabilitation and restoration actions.

Finally, the results of research and monitoring by all engaged entitites will provide valuable information to assist the Forest Service in their management and stewardship of the Fossil Creek area and watershed.

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APPENDICES

Appendix A.

Greater Fossil Creek Plant List

(Adapted from the USFS Fossil Creek Database))

Scientific Name	Common Name	Family	Observation Location
Abies concolor	White fir	Pinaceae	Fossil Creek Riparian
Abutilon incanum	Indian mallow	Malvaceae	Fossil Creek Upland
Acacia greggii	Catclaw acacia	Fabaceae	Fossil Springs Botanical Area
Acer grandidentata	Bigtooth maple	Aceraceae	Fossil Springs Riparian
Acer negundo	Box elder	Aceraceae	Fossil Springs Riparian
Acer negundo var. interius	Box elder	Aceraceae	Fossil Springs Riparian
Acer pseudoplatanus	Sycamore maple	Aceraceae	Fossil Springs Riparian
Acer grandidentatum	Big-tooth maple	Aceraceae	Fossil Springs Botanical Area
Acourtia wrightii	Brown-foot	Asteraceae	Fossil Creek Upland
Adiantum capillus-veneris	Maidenhair fern	Pteridaceae	Fossil Creek Riparian
Aegilops cylindrica	Jointed goatgrass	Poaceae	
Agave chrysantha	Yellow-flowered agave	Agavaceae	Fossil Creek Upland
Agave parryi	Parry's agave	Agavaceae	Fossil Springs Botanical Area
Agave sp.	Agave	Agavaceae	Fossil Creek Riparian
Ailanthes altissima	Tree-of-heaven	Simaroubaceae	
Allionia incarnata	Trailing four-o-clock	Nyctaginaceae	Fossil Springs Riparian
Allionia incarnata	Trailing four o' clock	Nyctaginaceae	Fossil Springs Botanical Area
Allionia incarnata	Trailing-four-o'clock	Nyctaginaceae	Fossil Creek Upland
Allium sp.	Onion	Liliaceae	Fossil Springs Botanical Area
Alnus oblongifolia	Arizona alder	Betulaceae	Fossil Springs Riparian
Alnus oblongifolia	Arizona alder	Betulaceae	Fossil Creek Riparian-East Bank-Spring
Aloysia wrightii	Wright's beebrush	Verbenaceae	Fossil Springs Botanical Area
Ambrosia sp.	Ragweed	Asteraceae	Fossil Creek Riparian
Amsinckia intermedia	Fiddleneck	Boraginaceae	Fossil Springs Botanical Area

Anemone tuberosa	Desert anemone	Ranunculaceae	Fossil Springs Botanical Area
Anisacanthus thurberi	Desert honeysuckle	Acanthaceae	Fossil Creek Riparian
Aquilegia chrysantha	Yellow columbine	Ranunculaceae	Fossil Springs Riparian
Aquilegia sp.	Columbine	Ranunculaceae	Fossil Springs Riparian
Arabis perennans	Perennial rockcress	Brassicaceae	Fossil Creek Upland
Arctostaphylos pringlei	Pringlei manzanita	Ericaceae	Fossil Springs Botanical Area
Arctostaphylos pungens	Pointleaf manzanita	Ericaceae	Fossil Springs Botanical Area
Argemone pleiacantha	Bluestem pricklepoppy	Asteraceae	Fossil Creek Upland
Artemisia ludoviciana	Silver wormwood	Asteraceae	Fossil Creek Upland
Arundo donax	Giant reed	Poaceae	
Asclepias asperula capricornu	Antelope-horn	Asclepiadaceae	Fossil Creek Upland
Aster sp.	Aster	Asteraceae	Fossil Creek Riparian
Astragalus wootoni	Milkvetch, locoweed	Fabaceae	Fossil Springs Botanical Area
Astrolepis sinuata	Wavy-cloak fern	Pteridaceae	Fossil Creek Upland
Atriplex canescens	Four-wing saltbush	Chenopodiaceae	Fossil Creek Upland
Avena fatua	Wild oats	Poaceae	
Baccharis arothroides	Desert-broom	Asteraceae	Fossil Creek Upland
Baccharis brachyphylla	Short leaved baccharis	Asteraceae	Fossil Creek Upland
Baccharis glutinosa	Seepwillow	Asteraceae	Fossil Creek Riparian
Baccharis pteroniodides	Hierba de pasmo	Asteraceae	Fossil Creek Upland
Baccharis salicifolia	Seep willow	Asteraceae	Fossil Springs Botanical Area
Baccharis salicifolia	Seep willow	Asteraceae	Fossil Creek Riparian
Baccharis sarothroides	Desert broom	Asteraceae	Fossil Creek Riparian
Baileya multiradiata	Desert-marigold	Asteraceae	Fossil Creek Upland
Berberis fremontii	Fremont barberry	Berberidaceae	Fossil Springs Botanical Area
Berberis haematocarpa	Desert barberry	Berberidaceae	Fossil Creek Upland
Bothriochola barbinodis	Cane bluestem	Poaceae	Fossil Springs Botanical Area
Brickellia grandiflora	Tasselflower brickellbush	Asteraceae	Fossil Springs Botanical Area
Bromus japonicus	Japanese brome	Poaceae	
Bromus madritensis	Foxtail chess	Poaceae	
Bromus diandrus	Ripgut brome	Poaceae	

Bromus tectorum	Cheatgrass	Poaceae	
Caesalpinia gilliesii	Bird-of-paradise	Fabaceae	Fossil Creek Upland
Calliandra humilis	Dwarf fairy-duster	Fabaceae	Fossil Creek Upland
Canotia holacantha	Canotia	Celastraceae	Fossil Springs Botanical Area
Capsella bursa-pastoris	Shepherd's purse	Brassicaceae	Fossil Springs Botanical Area
Carex sp.	Sedge	Cyperaceae	Fossil Creek Riparian
Castilleja integra var. integra	Indian-paintbrush	Scrophulariaceae	Fossil Creek Upland
Ceanothus greggii	Greg ceanothus	Rhamnaceae	Fossil Springs Botanical Area
Ceanothus integerrimus	Deerbrush	Rhamnaceae	Fossil Springs Botanical Area
Ceanothus sp.		Rhamnaceae	Fossil Creek Riparian
Celtis reticulata	Net-leaf hackberry	Ulmaceae	Fossil Creek Upland
Centaurea solstitialis	Yellow starthistle	Asteraceae	
Cercocarpus montanus	Mountain-mahogany	Rosaceae	Fossil Creek Upland
Chaetopappa ericoides	Upland-daisy	Asteraceae	Fossil Creek Upland
Chamaesyce polycarpa	Small-seeded sand mat	Euphorbiaceae	Fossil Creek Upland
Chara sp.	Muskgrass	Characeae	Fossil Creek Riparian
Cheilanthes sp.	Fern	Polypodiaceae	Fossil Springs Botanical Area
Chenopodium fremontii	Fremont goose-foot	Chenopodiaceae	Fossil Creek Upland
Chilopsis linearifolia	Desert willow	Bignoniaceae	Fossil Creek Riparian
Chorispora tenella	Blue mustard	Brassicaceae	
Cirsium neomexicanum	New Mexican thistle	Asteraceae	Fossil Creek Upland
Cirsium sp.	Thistle	Asteraceae	Fossil Springs Botanical Area
Cirsium vulgare	Bull thistle	Asteraceae	
Claytonia perfoliata	Miner's lettuce	Portulacaceae	Fossil Springs Botanical Area
Clematis ligusticifolia	White virgin's bower	Ranunculaceae	Fossil Springs Botanical Area
Cleome lutea	Yellow bee plant	Cleomaceae	Fossil Springs Botanical Area
Comandra umbellata	Bastard-toadflax	Santalaceae	Fossil Creek Upland
Conium maculatum	Poison hemlock	Apiaceae	Fossil Creek Riparian-Spring 15
Convolvulus equitans	Hoary bindweed	Convolvulaceae	Fossil Creek Upland
Cordylanthus laxiflorus	Yellow bird-beak	Scrophulariaceae	Fossil Creek Upland
Cortaderia selloana	Pampas grass	Poaceae	
Corydalis aurea	Golden corydalis	Fumariaceae	Fossil Springs Botanical Area

Coryphantha vivipara var. arizonica	Pincushion cactus	Cactaceae	Fossil Creek Upland
Cryptantha barbigera	Bearded cryptantha	Boraginaceae	Fossil Creek Upland
Cupressus arizonica	Arizona cypress	Cupressaceae	Fossil Springs Botanical Area
Cuscuta indecora	Pretty dodder	Convolvulaceae	Fossil Creek Riparian
Cynodon dactylon	Bermuda grass	Poaceae	
Cynodon dactylon	Crab grass	Poaceae	Fossil Creek Riparian
Cynodon dactylon	Bermuda grass	Poaceae	Fossil Springs Botanical Area
Cynodon sp.	Grass	Poaceae	Fossil Creek Riparian
Dalea albiflora	Scruffy prairie clover	Fabaceae	Fossil Springs Botanical Area
Dalea formosa	Feather dalea	Fabaceae	Fossil Springs Botanical Area
Datura meteloides	Sacred datura	Fabaceae	Fossil Springs Riparian
Datura meteloides	Sacred datura	Solanaceae	Fossil Springs Botanical Area
Datura meteloides	Sacred datura	Solanaceae	Fossil Creek Upland
Daucus carota	Wild carrot	Apiaceae	Fossil Springs Botanical Area
Delphinium scaposum	Barestem larkspur	Ranunculaceae	Fossil Springs Botanical Area
Delphinium sp.	Larkspur	Ranunculaceae	Fossil Creek Riparian
Descurainia pinnata	Tansy mustard	Brassicaceae	Fossil Springs Botanical Area
Desmodium neomexicana	New Mexico tickclover	Fabaceae	Fossil Springs Riparian
Dichelostemma pulchellum	Bluedicks	Liliaceae	Fossil Springs Botanical Area
Drypanocladus sp.	Moss		Fossil Springs Riparian
Echinocereus coccineus	Claret-cup cactus	Cactaceae	Fossil Creek Upland
Echinocereus fasciculatus	Hedgehog cactus	Cactaceae	Fossil Creek Upland
Echinocereus triglochidiatus	Claret cup cactus	Cactaceae	Fossil Springs Botanical Area
Echinochloa crusgali	Barnyard grass	Poaceae	Fossil Springs Botanical Area
Echinochloa crusgalli	Barnyard grass	Poaceae	Fossil Springs Riparian
Eleocharis sp.	Spikerush	Cyperaceae	Fossil Creek Riparian
Elymus elymoides	Squirrel-tail	Poaceae	Fossil Creek Upland
Elymus glaucus	Blue wild-rye	Poaceae	Fossil Creek Upland
Elymus sp.	Foxtail	Poaceae	Fossil Creek Riparian
Elymus sp.	Wild rye	Poaceae	Fossil Creek Riparian
Ephedra viridis	Joint fir	Ephedraceae	Fossil Springs Botanical Area

Ephedra viridis var. viscida	Mountain joint-fir	Ephedraceae	Fossil Creek Upland
Epilobium brachycarpum	Fireweed	Onagraceae	Fossil Creek Riparian
Epipactis gigantea	Helleborine	Orchidaceae	Fossil Creek Riparian
Epipactis gigantea	Helleborine	Orchidaceae	Fossil Springs Botanical Area
Equisetum arvense	Horsetail	Equisetaceae	Fossil Springs Riparian
Equisetum arvense	Horsetail	Equisetaceae	Fossil Creek Riparian
Equisetum arvense	Horsetail	Equisetaceae	Fossil Creek Riparian-East Bank-Spring
Equisetum arvense	Horsetail	Equisetaceae	Fossil Springs Riparian
Equisetum arvense	Horsetail	Equisetaceae	Fossil Springs Botanical Area
Equisetum laevigatum	Horsetail	Equisetaceae	Fossil Springs Botanical Area
Equisetum sp.	Horsetail	Equisetaceae	Fossil Creek Riparian
Equisetum sp.	Horsetail	Equisetaceae	Fossil Creek Riparian
Eragrostis intermedia	Plains lovegrass	Poaceae	Fossil Springs Riparian
Eragrostis intermedia	Plains lovegrass	Poaceae	Fossil Springs Botanical Area
Eragrostis lehmanniana	Lehmann's lovegrass	Poaceae	
Eragrostis lehmanniana	Lehmann lovegrass	Poaceae	Fossil Creek Upland
Eriastrum diffusum	Miniature wool star	Polemoniaceae	Fossil Creek Riparian
Ericameria laricifoia	Turpentine-bush	Asteraceae	Fossil Creek Upland
Erigeron divergens	Spreading fleabane	Asteraceae	Fossil Creek Upland
Erigeron divergens	Spreading fleabane	Asteraceae	Fossil Springs Botanical Area
Erigeron flagellaris	Running fleabane	Asteraceae	Fossil Springs Botanical Area
Erigeron flagellaris	Running fleabane	Asteraceae	Fossil Creek Upland
Eriodictyon angustifolium	Yerba santa	Hydrophyllaceae	Fossil Springs Botanical Area
Eriodictyon angustifolium	Yerba santa	Hydrophyllaceae	Fossil Creek Upland
Eriogonum abertianum	Wild buckwheat	Polygonaceae	Fossil Creek Upland
Eriogonum fasiculatum	Flat-top buckwheat	Polygonaceae	Fossil Creek Riparian
Eriogonum wrightii	Wright false-buckwheat	Polygonaceae	Fossil Creek Upland
Eriogonum wrightii	Wild buckwheat	Polygonaceae	Fossil Springs Botanical Area
Erioneuron pulchellum	Fluffgrass	Poaceae	Fossil Creek Upland
Erodium cicutarium	Redstem filaree	Geraniaceae	
Erodium cicutarium	Filaree	Geraniaceae	Fossil Creek Riparian

Erodium cicutarium	Filaree	Geraniaceae	Fossil Creek Upland
Erodium cicutarium	Filaree	Geraniaceae	Fossil Springs Botanical Area
Erysimum asperum var. capitatum	Wallflower	Brassicaceae	Fossil Springs Botanical Area
Euphorbia lurida	Euphorbia	Euphorbiaceae	Fossil Springs Botanical Area
Euphorbia sp.	Spurge	Euphorbiaceae	Fossil Creek Riparian
Fendlera rupicola	Fendlerbush	Saxifragaceae	Fossil Springs Botanical Area
Ferocactus cylindraceus	California barrel cactus	Cactaceae	Fossil Creek Upland
Ferocactus wislizenii	Candy barrel cactus	Cactaceae	Fossil Creek Riparian
Festuca arundinacea	Tall fescue	Poaceae	
Festuca sp.	Fescue	Poaceae	Fossil Springs Botanical Area
Ficus carica	Fig	Moraceae	Fossil Springs Botanical Area
Ficus carica	Fig	Moraceae	Fossil Springs Riparian
Ficus carica	Fig	Moraceae	Fossil Creek Riparian-Spring 28
Forestiera pubescens	Desert olive	Oleaceae	Fossil Springs Botanical Area
Forestiera pubescens	Desert-olive	Oleaceae	Fossil Creek Upland
Fouquieria splendens	Ocotillo	Fouquieriaceae	Fossil Creek Riparian
Fouquieria splendens	Ocotillo	Fouquieriaceae	Fossil Creek Upland
Fraxinus anomala	Ash	Oleaceae	Fossil Springs Botanical Area
Fraxinus anomala var. lowellii	Lowell ash	Oleaceae	Fossil Creek Upland
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Springs Riparian
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-East Bank-Spring
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 22
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 21
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 20
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Springs Botanical Area
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 19
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 17
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 16
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 14

Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 11
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 24
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 25
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 26
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 27
Fraxinus velutina	Velvet ash	Oleaceae	Fossil Creek Riparian-Spring 28
Gaillardia pulchella	Blanket flower	Asteraceae	Fossil Springs Botanical Area
Galium aparine	Bedstraw	Rubiaceae	Fossil Creek Upland
Galium aparine	Bedstraw	Rubiaceae	Fossil Creek Riparian
Galium aparine	Bedstraw	Rubiaceae	Fossil Springs Botanical Area
Galium sp.		Rubiaceae	Fossil Springs Botanical Area
Galium stellatum	Desert bedstraw	Rubiaceae	Fossil Creek Upland
Galium stellatum	Desert bedstraw	Rubiaceae	Fossil Springs Botanical Area
Galium stellatum	Desert bedstraw	Rubiaceae	Fossil Springs Riparian
Garrya flavescens	Quinine bush	Garryaceae	Fossil Springs Botanical Area
Garrya sp.	Silk tassel bush	Garryaceae	Fossil Creek Riparian
Garrya wrightii	Wright’s silk tassel	Garryaceae	Fossil Creek Upland
Garrya wrightii	Wright’s silk tassel	Garryaceae	Fossil Springs Botanical Area
Gaura coccinea	Scarlet gaura	Onagraceae	Fossil Creek Upland
Geranium caespitosum	Wild geranium	Geraniaceae	Fossil Springs Botanical Area
Geranium caespitosum	Wild geranium	Geraniaceae	Fossil Springs Riparian
Geranium fremontii	Geranium	Geraniaceae	Fossil Springs Botanical Area
Geranium sp.	Wild geranium	Geraniaceae	Fossil Springs Botanical Area
Geranium sp.	Wild geranium	Geraniaceae	Fossil Creek Riparian
Geranium sp.	Wild geranium	Geraniaceae	Fossil Springs Riparian
Geranium sp.	Wild geranium	Geraniaceae	Fossil Creek Riparian-East Bank-Spring
Gilia flavocincta	Lesser yellowthroat gilia	Polemoniaceae	Fossil Springs Botanical Area
Gilia gilliodes	Sticky false gilyflower	Polemoniaceae	Fossil Creek Riparian
Gleditsia triacanthos	Honeylocust	Fabaceae	
Gnaphalium canescens	Cudweed	Asteraceae	Fossil Creek Upland
Gutierezia sarothrae	Broom snakeweed	Asteraceae	Fossil Creek Upland
Gutierrezia microcephala	Snakeweed	Asteraceae	Fossil Springs Botanical Area

Happlopappus gracilis	Goldenweed	Asteraceae	Fossil Springs Botanical Area
Hedeoma drummondii	Drummond's false pennyroyal	Lamiaceae	Fossil Creek Upland
Helianthus annuus	Common sunflower	Asteraceae	Fossil Springs Riparian
Helianthus annuus	Common sunflower	Asteraceae	Fossil Springs Botanical Area
Heliomeris longifolia var. annua	Annual golden-eye	Asteraceae	Fossil Creek Upland
Hilaria belangeri	Curly mesquite grass	Poaceae	Fossil Creek Upland
Hordeum murinum ssp. leporinum	Mediterranean barley	Poaceae	
Hordeum leporinum	Barley	Poaceae	Fossil Springs Botanical Area
Hymenopappus filifolius var. lugens	Lace-daisy	Asteraceae	Fossil Creek Upland
Ipomopsis aggregata	Sky-rocket	Polemoniaceae	Fossil Creek Upland
Iris sp.	Iris	Iridaceae	
Iris missouriensis	Rocky Mountain iris	Iridaceae	Fossil Creek Riparian
Iris missouriensis	Rocky Mountain iris	Iridaceae	Fossil Springs Botanical Area
Juglans major	Arizona walnut	Juglandaceae	Fossil Creek Riparian-East Bank-Spring
Juglans major	Arizona walnut	Juglandaceae	Fossil Creek Riparian-East Bank-Spring
Juglans major	Arizona walnut	Juglandaceae	Fossil Creek Riparian-East Bank-Spring
Juglans major	Arizona walnut	Juglandaceae	Fossil Creek Riparian
Juglans major	Arizona walnut	Juglandaceae	Fossil Creek Riparian-East Bank-Spring
Juglans major	Arizona walnut	Juglandaceae	Fossil Springs Botanical Area
Juglans major	Arizona walnut	Juglandaceae	Fossil Springs Riparian
Juglans major	Arizona walnut	Juglandaceae	Fossil Creek Upland
Juglans major	Arizona walnut	Juglandaceae	Fossil Creek Riparian
Juglans major	Arizona walnut	Juglandaceae	Fossil Creek Riparian-East Bank-Spring
Juncus sp.	Rush	Juncaceae	Fossil Springs Botanical Area
Juncus sp.	Rush	Juncaceae	Fossil Springs Riparian
Juncus torreyi	Bur rush	Juncaceae	Fossil Creek Riparian
Juniperus coahuilensis	Coahuila juniper	Cupressaceae	Fossil Creek Upland

Juniperus deppeana	Alligator juniper	Cupressaceae	Fossil Creek Riparian
Juniperus deppeana	Alligator juniper	Cupressaceae	Fossil Creek Upland
Juniperus deppeana	Alligator juniper	Cupressaceae	Fossil Springs Botanical Area
Juniperus deppeana	Alligator juniper	Cupressaceae	Fossil Springs Riparian
Juniperus osteosperma	Utah juniper	Cupressaceae	Fossil Springs Riparian
Juniperus osteosperma	Utah juniper	Cupressaceae	Fossil Creek Riparian
Juniperus osteosperma	Utah juniper	Cupressaceae	Fossil Springs Botanical Area
Juniperus sp.	Juniper	Cupressaceae	Fossil Creek Riparian
Keckiella antirrhinoides	Bush-penstemon	Scrophulariaceae	Fossil Creek Upland
Koeberlinia spinosa	Allthorn	Capparaceae	Fossil Creek Riparian
Krameria parvifolia	Range ratany	Krameriaceae	Fossil Creek Riparian
Lactuca graminifolia	Grassleaf lettuce	Asteraceae	Fossil Springs Riparian
Lactuca gramnifolia	Grassleaf lettuce	Asteraceae	Fossil Springs Botanical Area
Lactuca serriola	Prickly lettuce	Asteraceae	
Lamium amplexicaule	Dead nettle, henbit	Lamiaceae	
Lappula redowski	Stickseed	Berberidaceae	Fossil Springs Botanical Area
Lathyrus latifolius	Perennial sweetpea	Fabaceae	
Lepidium lasiocarpum	Sand peppergrass	Brassicaceae	Fossil Creek Upland
Leptochloa dubia	Green sprangletop	Poaceae	Fossil Creek Upland
Leptodictyum riparium	Moss		Fossil Creek Riparian
Leucelene ericoides	Baby aster	Asteraceae	Fossil Springs Botanical Area
Lithospermum incisum	Fringed gromwell	Boraginaceae	Fossil Springs Botanical Area
Lobelia cardinalis	Cardinal flower	Campanulaceae	Fossil Springs Riparian
Lobelia cardinalis	Cardinal flower	Campanulaceae	Fossil Creek Riparian
Lobelia cardinalis s. graminea	Cardinal flower	Campanulaceae	Fossil Springs Botanical Area
Lonicera albiflora var. dumosa	Honeysuckle	Caprifoliaceae	Fossil Springs Botanical Area
Lotus humistratus	Hill-locust	Fabaceae	Fossil Creek Upland
Lotus rigidus	Desert rock-pea	Fabaceae	Fossil Creek Upland
Lotus rigidus	Desert rock-pea	Fabaceae	Fossil Creek Riparian
Lotus wrightii	Wright deer-vetch	Fabaceae	Fossil Creek Upland
Lycium pallidum	Wolfberry	Solanaceae	Fossil Creek Upland

Lycium pallidum	Wolfberry	Solanaceae	Fossil Springs Botanical Area
Machaeranthera canescens	Hoary-aster	Asteraceae	Fossil Creek Upland
Machaeranthera canescens	Hoary-aster	Asteraceae	Fossil Springs Botanical Area
Machaeranthera gracilis	Little yellow-aster	Asteraceae	Fossil Creek Upland
Machaeranthera tanacetifolia	Tansyleaf spine aster	Asteraceae	Fossil Springs Botanical Area
Machaeranthera tanacetifolia	Tansyleaf spine aster	Asteraceae	Fossil Creek Upland
Mahonia trifoliolata	Algerita	Berberidaceae	Fossil Creek Riparian
Malva parviflora	Cheeseweed, little	Malvaceae	
Marrubium vulgare	Horehound	Lamiaceae	Fossil Creek Upland
Marrubium vulgare	Horehound	Lamiaceae	
Marrubium vulgare	Horehound	Lamiaceae	Fossil Springs Botanical Area
Matelea producta	Trailing-hearts	Asclepiadaceae	Fossil Creek Upland
Maurandella antirrhiniflora	Climbing snapdragon	Scrophulariaceae	Fossil Creek Upland
Maurandya antirrhiniflora	Climbing snapdragon	Scrophulariaceae	Fossil Springs Botanical Area
Medicago polymorpha	Burclover	Fabaceae	Fossil Springs Botanical Area
Medicago polymorpha	Burclover	Fabaceae	
Medicago sp.		Fabaceae	Fossil Creek Riparian
Melampodium leucanthum	Black-foot	Asteraceae	Fossil Creek Upland
Melampodium leucanthum	Blackfoot daisy	Asteraceae	Fossil Springs Riparian
Melampodium leucanthum	Blackfoot daisy	Asteraceae	Fossil Springs Botanical Area
Melilotus alba	White sweet clover	Fabaceae	Fossil Springs Riparian
Melilotus alba	White sweet clover	Fabaceae	Fossil Springs Botanical Area
Melilotus alba	White sweet clover	Fabaceae	Fossil Creek Riparian
Melilotus indicus	Sour clover	Fabaceae	Fossil Springs Botanical Area
Melilotus officinalis	Yellow sweet clover	Fabaceae	Fossil Springs Riparian
Melilotus officinalis	Yellow sweet clover	Fabaceae	
Melilotus officinalis	Yellow sweet clover	Fabaceae	Fossil Creek Upland
Melilotus officinalis	Yellow sweet clover	Fabaceae	Fossil Springs Botanical Area
Melilotus sp.	Sweet clover	Fabaceae	Fossil Creek Riparian
Menodora scabra	Twinberry	Oleaceae	Fossil Creek Upland
Mentizelia multifora .	Blazing-star	Loasaceae	Fossil Creek Upland
Mentzelia pumila	Desert blazing star	Loasaceae	Fossil Springs Botanical Area

Mentzelia pumila	Desert blazing star	Loasaceae	Fossil Springs Riparian
Mimosa biuncifera	Wait-a-minute bush	Fabaceae	Fossil Springs Botanical Area
Mimulus guttatus	Monkey flower	Scrophulariaceae	Fossil Creek Riparian
Mimulus guttatus	Monkey flower	Scrophulariaceae	Fossil Springs Riparian
Mimulus guttatus	Monkey flower	Scrophulariaceae	Fossil Springs Botanical Area
Mimulus guttatus	Monkey flower	Scrophulariaceae	Fossil Creek Upland
Mimulus rubellus	Monkey flower	Scrophulariaceae	Fossil Springs Botanical Area
Mirabilis bigelovi	Ribbon four o' clock	Nyctaginaceae	Fossil Springs Botanical Area
Mirabilis multiflora	Colorado four o'clock	Nyctaginaceae	Fossil Springs Botanical Area
Mirabilis multiflora	Colorado four o'clock	Nyctaginaceae	Fossil Creek Upland
Mirbilis pumila	Little four o'clock	Nyctaginaceae	Fossil Creek Upland
Montia chamissoi	Chamisso's montia	Portulacaceae	Fossil Springs Botanical Area
Morus microphylla	Texas mulberry	Moraceae	Fossil Creek Upland
Morus microphylla	Texas mulberry	Moraceae	Fossil Creek Riparian
Muhlenbergia emersleyi	Bullgrass	Poaceae	Fossil Creek Upland
Muhlenbergia porteri	Bush muhly	Poaceae	Fossil Creek Upland
Muhlenbergia rigens	Deergrass	Poaceae	Fossil Creek Riparian
Muhlenbergia rigens	Deergrass	Poaceae	Fossil Springs Riparian
Muhlenbergia rigens	Deergrass	Poaceae	Fossil Creek Riparian
Muhlenbergia rigens	Deergrass	Poaceae	Fossil Springs Riparian
Muhlenbergia rigens	Deergrass	Poaceae	Fossil Springs Botanical Area
Nicotiana trigonophylla	Desert tobacco	Solanaceae	Fossil Creek Upland
Nicotiana trigonophylla	Desert tobacco	Solanaceae	Fossil Springs Botanical Area
Nolina microcarpa	Beargrass	Agavaceae	Fossil Springs Botanical Area
Nolina microcarpa	Beargrass	Agavaceae	Fossil Creek Upland
Nolina microcarpa	Beargrass	Agavaceae	Fossil Creek Riparian
Opuntia acanthocarpa	Staghorn cholla	Cactaceae	Fossil Creek Upland
Opuntia chlorotica	Pancake prickly pear	Cactaceae	Fossil Creek Upland
Opuntia engelmannii	Engelmann prickly pear	Cactaceae	Fossil Creek Upland
Opuntia leptocaulis	Desert Christmas cactus	Cactaceae	Fossil Creek Upland
Opuntia leptocaulis	Desert Christmas cactus	Cactaceae	Fossil Springs Botanical Area

Opuntia phaeacantha	Brown-spined prickly pear	Cactaceae	Fossil Springs Botanical Area
Opuntia phaeacantha	Brown-spined prickly pear	Cactaceae	Fossil Creek Upland
Opuntia sp.	Prickly pear	Cactaceae	Fossil Creek Riparian
Oxalis albicans ssp. pilosa	Canyon sorrel	Oxalidaceae	Fossil Creek Upland
Oxalis albicans ssp. pilosa	Canyon sorrel	Oxalidaceae	Fossil Springs Botanical Area
Parietaria hespera	Pellitory	Urticaceae	Fossil Springs Botanical Area
Parietaria hespera	Pellitory	Urticaceae	Fossil Creek Upland
Parthenium incanum	Mariola	Asteraceae	Fossil Creek Upland
Parthenocissus quinquefolia	Virginia creeper	Vitaceae	Fossil Springs Riparian
Parthenocissus quinquefolia	Virginia creeper	Vitaceae	Fossil Creek Upland
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Springs Botanical Area
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-Spring 28
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-Spring 27
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-Spring 26
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-Spring 17
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-Spring 24
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-Spring 23
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-Spring 18
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-Spring 19
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Springs Riparian
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-Spring 25
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-East Bank-Spring
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-Spring 11
Parthenocissus vitacea	Woodbine	Vitaceae	Fossil Creek Riparian-Spring 15
Pascopyrum smithii	Western wheatgrass	Poaceae	Fossil Creek Upland
Pellaea truncata	Cliff-brake	Polypodiaceae	Fossil Creek Upland
Penstemon linarioides	Linaria-leaf penstemon	Scrophulariaceae	Fossil Creek Upland
Penstemon eatoni	Eaton firecracker	Scrophulariaceae	Fossil Springs Botanical Area
Penstemon eatoni	Eaton firecracker	Scrophulariaceae	Fossil Creek Upland
Penstemon microphyllus	Bush penstemon	Scrophulariaceae	Fossil Creek Riparian

Penstemon pseudospectabilis	Mojave penstemon	Scrophulariaceae	Fossil Creek Upland
Penstemon pseudospectalbilis	Desert penstemon	Scrophulariaceae	Fossil Springs Botanical Area
Penstemon sp.	Penstemon	Scrophulariaceae	Fossil Springs Riparian
Penstemon sp.	Penstemon	Scrophulariaceae	Fossil Creek Riparian-Spring 16
Penstemon sp.	Penstemon	Scrophulariaceae	Fossil Creek Riparian
Penstemon sp.	Penstemon	Scrophulariaceae	Fossil Creek Riparian-East Bank-Spring
Penstemon sp.	Penstemon	Scrophulariaceae	Fossil Creek Riparian-East Bank-Spring
Penstemon sp.	Penstemon	Scrophulariaceae	Fossil Creek Riparian
Perityle ciliata	Fringed rockdaisy	Asteraceae	Fossil Springs Botanical Area
Perityle ciliata	Fringed rockdaisy	Asteraceae	Fossil Springs Riparian
Phacelia cryptantha	Hiddenflower phacelia	Hydrophyllaceae	Fossil Creek Riparian
Phacelia sp.	Phacelia	Hydrophyllaceae	Fossil Springs Botanical Area
Phalaris minor	Littleseed canarygrass	Poaceae	
Phaseolus angustissimus	Slimleaf limabean	Fabaceae	Fossil Creek Upland
Phaseolus angustissimus	Slimleaf limabean	Fabaceae	Fossil Creek Riparian
Phaseolus angustissimus	Slimleaf limabean	Fabaceae	Fossil Springs Botanical Area
Phoradendron coryae	Oak mistletoe	Viscaceae	Fossil Creek Upland
Phoradendron juniperinum	Juniper mistletoe	Viscaceae	Fossil Creek Upland
Phoradendron juniperinum	Juniper mistletoe	Viscaceae	Fossil Springs Botanical Area
Phoradendron villosum var. coryae	Mistletoe	Viscaceae	Fossil Springs Botanical Area
Pinus edulis	Pinyon pine	Pinaceae	Fossil Springs Riparian
Pinus edulis	Pinyon pine	Pinaceae	Fossil Springs Botanical Area
Pinus edulus	Pinyon pine	Pinaceae	Fossil Creek Riparian
Pinus monophylla	Singleleaf pinyon	Pinaceae	Fossil Springs Botanical Area
Pinus monophylla	Singleleaf pinyon	Pinaceae	Fossil Creek Riparian
Pinus ponderosa	Ponderosa pine	Pinaceae	Fossil Springs Riparian
Pinus ponderosa	Ponderosa pine	Pinaceae	Fossil Creek Riparian
Pinus ponderosa	Ponderosa pine	Pinaceae	Fossil Springs Botanical Area
Pinus sp.	Pine	Pinaceae	Fossil Creek Riparian

Plantago major	Common plantain	Plantaginaceae	
Plantago major	Common plantain	Plantaginaceae	Fossil Springs Botanical Area
Plantago patagonica	Silky plantain	Plantaginaceae	Fossil Creek Upland
Plantago sp.	Plantain	Plantaginaceae	Fossil Creek Riparian
Platanus wrightii	Arizona sycamore	Platanaceae	Fossil Springs Botanical Area
Platanus wrightii	Arizona sycamore	Platanaceae	Fossil Springs Riparian
Platanus wrightii	Arizona sycamore	Platanaceae	Fossil Creek Riparian
Platanus wrightii	Arizona sycamore	Platanaceae	Fossil Creek Upland
Poa fendleriana	Muttongrass	Poaceae	Fossil Springs Riparian
Poa fendleriana	Muttongrass	Poaceae	Fossil Springs Botanical Area
Poa fendleriana	Muttongrass	Poaceae	Fossil Creek Riparian-East Bank-Spring
Poa sp.	Bluegrass	Poaceae	Fossil Creek Riparian
Polygonum coccineum	Smartweed, knotweed	Polygonaceae	Fossil Springs Botanical Area
Polygonum coccineum	Smartweed, knotweed	Polygonaceae	Fossil Springs Riparian
Polypogon monspeliensis	Rabbitfoot	Poaceae	Fossil Springs Botanical Area
Polypogon monspeliensis	Rabbitfoot	Poaceae	Fossil Springs Riparian
Polypogon monspeliensis	Rabbitfoot	Poaceae	Fossil Creek Riparian
Polypogon viridis	Beard grass	Poaceae	Fossil Creek Upland
Populus fremontii	Fremont cottonwood	Salicaceae	Fossil Springs Riparian
Populus fremontii	Fremont cottonwood	Salicaceae	Fossil Springs Botanical Area
Populus fremontii	Fremont cottonwood	Salicaceae	Fossil Creek Upland
Populus fremontii	Fremont cottonwood	Salicaceae	Fossil Creek Riparian
Potamageton sp.	Pondweed	Haloragaceae	Fossil Creek Riparian
Prosopis glandulosa	Western honey mesquite	Fabaceae	Fossil Springs Botanical Area
Prosopis velutina	Mesquite	Fabaceae	Fossil Creek Riparian
Prosopis velutina	Velvet mesquite	Fabaceae	Fossil Springs Botanical Area
Prosopis velutina	Velvet mesquite	Fabaceae	Fossil Creek Upland
Prunella vulgaris	Selfheal	Lamiaceae	
Prunus virginiana	Common chokecherry	Rosaceae	Fossil Creek Riparian
Prunus virginiana	Common chokecherry	Rosaceae	Fossil Springs Botanical Area
Psoralidium tenuiflorum	Scurvy pea	Fabaceae	Fossil Creek Upland
Ptelea trifoliata	Narrowleaf hoptree	Rutaceae	Fossil Creek Riparian-Spring 14

Ptelea trifoliata	Hop bush	Rutaceae	Fossil Springs Riparian
Ptelea trifoliata	Hop tree	Rutaceae	Fossil Springs Botanical Area
Pteridium aquilinum	Bracken fern	Polypodiaceae	Fossil Creek Riparian
Purshia stansburiana	Cliffrose	Rosaceae	Fossil Creek Upland
Purshia stansburiana	Cliffrose	Rosaceae	Fossil Springs Botanical Area
Quercus arizonica	Arizona white oak	Fagaceae	Fossil Springs Botanical Area
Quercus chrysolepsis	Canyon live oak	Fagaceae	Fossil Springs Botanical Area
Quercus emoryi	Emory oak	Fagaceae	Fossil Springs Botanical Area
Quercus gambelii	Gambel oak	Fagaceae	Fossil Creek Upland
Quercus gambelii	Gambel oak	Fagaceae	Fossil Springs Botanical Area
Quercus dunnii	Palmer oak	Fagaceae	Fossil Creek Upland
Quercus rugosa	Netleaf oak	Fagaceae	Fossil Springs Botanical Area
Quercus turbinella	Shrub live oak	Fagaceae	Fossil Creek Riparian
Quercus turbinella	Scrub live oak	Fagaceae	Fossil Creek Upland
Quercus turbinella	Shrub live oak	Fagaceae	Fossil Springs Botanical Area
Ranunculus cymbalaria	Desert crowfoot	Ranunculaceae	Fossil Springs Botanical Area
Ranunculus cymbalaria	Desert crowfoot	Ranunculaceae	Fossil Springs Riparian
Rhamnus californica	California buckthorn	Rhamnaceae	Fossil Creek Riparian-Spring 17
Rhamnus californica	California buckthorn	Rhamnaceae	Fossil Creek Riparian
Rhamnus californica	California buckthorn	Rhamnaceae	Fossil Springs Riparian
Rhamnus californica	California buckthorn	Rhamnaceae	Fossil Springs Botanical Area
Rhamnus californica	California buckthorn	Rhamnaceae	Fossil Creek Riparian-East Bank-Spring
Rhamnus californica	California buckthorn	Rhamnaceae	Fossil Creek Riparian-Spring 19
Rhamnus californica	California buckthorn	Rhamnaceae	Fossil Creek Riparian-Spring 25
Rhamnus californica	California buckthorn	Rhamnaceae	Fossil Creek Upland
Rhamnus crocea	Hollyleaf buckthorn	Rhamnaceae	Fossil Creek Riparian
Rhamnus crocea	Hollyleaf buckthorn	Rhamnaceae	Fossil Springs Botanical Area
Rhamnus crocea	Red berry buckthorn	Rhamnaceae	Fossil Creek Upland
Rhus glabra	Smooth sumac	Anacardiaceae	Fossil Creek Riparian-East Bank-Spring
Rhus glabra	Smooth sumac	Anacardiaceae	Fossil Creek Riparian
Rhus glabra	Smooth sumac	Anacardiaceae	Fossil Springs Botanical Area
Rhus glabra	Smooth sumac	Anacardiaceae	Fossil Springs Riparian

Rhus ovata	Sugar sumac	Anacardiaceae	Fossil Creek Upland
Rhus ovata	Sugar sumac	Anacardiaceae	Fossil Springs Botanical Area
Rhus trilobata	Skunk bush	Anacardiaceae	Fossil Creek Riparian
Rhus trilobata	Skunk bush	Anacardiaceae	Fossil Springs Botanical Area
Ribes aureum	Golden currant	Saxifragaceae	Fossil Springs Botanical Area
Robinia neomexicana	New Mexico locust	Fabaceae	Fossil Creek Upland
Robinia neomexicana	New Mexico locust	Fabaceae	Fossil Springs Botanical Area
Robinia neomexicana	New Mexico locust	Fabaceae	Fossil Creek Riparian
Rorippa nasturtium aquaticum	White watercress	Brassicaceae	Fossil Springs Riparian
Rorippa nasturtium-aquaticum	White watercress	Brassicaceae	Fossil Creek Riparian-Spring 27
Rorippa nasturtium-aquaticum	White watercress	Brassicaceae	Fossil Creek Riparian-East Bank-Spring
Rorippa nasturtium-aquaticum	White watercress	Brassicaceae	Fossil Creek Riparian-Spring 16
Rorippa nasturtium-aquaticum	White watercress	Brassicaceae	Fossil Creek Riparian-Spring 21
Rorippa nasturtium-aquaticum	White watercress	Brassicaceae	Fossil Creek Riparian-Spring 25
Rorippa nasturtium-aquaticum	White Watercress	Brassicaceae	Fossil Creek Riparian
Rorippa nasturtium-aquaticum	White watercress	Brassicaceae	Fossil Creek Riparian-Spring 23
Rorippa nasturtium-aquaticum	White watercress	Brassicaceae	Fossil Creek Riparian-Spring 28
Rorippa nasturtium-aquaticum	White watercress	Brassicaceae	Fossil Creek Riparian-Spring 11
Rorippa nasturtium-aquaticum	White watercress	Brassicaceae	Fossil Creek Riparian-Spring 26
Rorippa nasturtium-aquaticum	White watercress	Brassicaceae	Fossil Creek Riparian-Spring 22
Rorippa nasturtium-aquaticum	White watercress	Brassicaceae	Fossil Creek Riparian-Spring 17
Rorippa sp.		Brassicaceae	Fossil Creek Riparian
Rosa woodsii	Wood rose	Rosaceae	Fossil Springs Botanical Area
Rubus arizonensis	Arizona dewberry	Rosaceae	Fossil Creek Riparian
Rubus arizonensis	Arizona dewberry	Rosaceae	Fossil Springs Botanical Area

Rubus arizonensis	Arizona dewberry	Rosaceae	Fossil Creek Upland
Rubus arizonensis	Arizona dewberry	Rosaceae	Fossil Springs Riparian
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 28
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-East Bank-Spring
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 26
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 27
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 25
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 13
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 18
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 24
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 17
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 14
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 16
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 19
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 22
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 23
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 15
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 20
Rubus procerus	Himalaya berry	Rosaceae	Fossil Creek Riparian-Spring 21
Rubus procerus	Himalaya berry	Rosaceae	Fossil Springs Riparian
Rubus sp.	Blackberry	Rosaceae	Fossil Springs Riparian
Rumex crispus	Curly dock	Polygonaceae	Fossil Springs Botanical Area
Salix bonplandiana	Willow	Salicaceae	Fossil Springs Botanical Area
Salix exigua	Coyote willow	Salicaceae	Fossil Springs Botanical Area
Salix gooddingii	Goodding willow	Salicaceae	Fossil Springs Botanical Area
Salix gooddingii	Goodding willow	Salicaceae	Fossil Springs Riparian
Salix gooddingii	Goodding willow	Salicaceae	Fossil Creek Riparian
Salix gooddingii	Goodding willow	Salicaceae	Fossil Creek Upland
Salix laevigata	Willow	Salicaceae	Fossil Springs Riparian
Salix sp.	Willow	Salicaceae	Fossil Creek Riparian
Salsola kali	Russian thistle	Chenopodiaceae	
Sapindus saponaria	Western soapberry	Sapindaceae	Fossil Creek Upland
Sapindus saponaria	Western soapberry	Sapindaceae	Fossil Springs Botanical Area

Sarcostemma cynanchoides	Climbing milkweed	Asclepiadaceae	Fossil Creek Riparian
Sarcostemma cynanchoides	Climbing-milkweed	Asclepiadaceae	Fossil Creek Upland
Scirpus acutus	Bulrush	Cyperaceae	Fossil Springs Riparian
Scirpus sp.	Bulrush	Cyperaceae	Fossil Creek Riparian
Scirpus validus	Bulrush	Cyperaceae	Fossil Springs Botanical Area
Senecio douglasii	Douglas groundsel	Asteraceae	Fossil Creek Upland
Senecio neomexicanus	Groundsel	Asteraceae	Fossil Springs Botanical Area
Senecio quercetorum	Groundsel	Asteraceae	Fossil Creek Upland
Senecio sp.	Groundsel	Asteraceae	Fossil Creek Riparian
Setaria leucophila	Bristlegrass	Poaceae	Fossil Springs Riparian
Seteria leucopila	Bristlegrass	Poaceae	Fossil Springs Botanical Area
Seteria sp.	Bristlegrass	Poaceae	Fossil Creek Riparian
Silene antirrhina	Sleepy catchfly	Caryophyllaceae	Fossil Creek Upland
Simmondsia chinensis	Jojoba	Simmondsiaceae	Fossil Creek Upland
Sisymbrium altissimum	Tumble mustard	Brassicaceae	
Sisymbrium irio	London rocket	Brassicaceae	
Solanum elaeagnifolium	Silverleaf nightshade	Solanaceae	Fossil Creek Upland
Solanum elaeagnifolium	Silverleaf nightshade	Solanaceae	Fossil Springs Botanical Area
Solidago sp.	Goldenrod	Asteraceae	Fossil Creek Riparian
Solidago sparsiflora	Few-flowered goldenrod	Asteraceae	Fossil Springs Botanical Area
Solidago sparsiflora	Few-flowered goldenrod	Asteraceae	Fossil Creek Upland
Solidago sparsiflora	Few-flowered goldenrod	Asteraceae	Fossil Springs Riparian
Sonchus asper	Spiny sowthistle	Asteraceae	
Sonchus oleraceus	Sowthistle	Asteraceae	
Sorghum halepense	Johnson grass	Poaceae	Fossil Springs Riparian
Sorghum halepense	Johnson grass	Poaceae	Fossil Springs Botanical Area
Sphaeralcea fendleri	Globemallow	Malvaceae	Fossil Springs Botanical Area
Sphaeralcea laxa	Globemallow	Malvaceae	Fossil Creek Upland
Sporobolus cryptandrus	Sand dropseed	Poaceae	Fossil Creek Upland
Stephanomeria pauciflora	Desert-straw	Asteraceae	Fossil Creek Upland
Stipa neomexicana	New Mexican	Poaceae	Fossil Creek Upland

Stipa speciosa	Desert needlegrass	Poaceae	Fossil Creek Upland
Tamarix chinensis	Salt cedar	Tamaricaceae	Fossil Creek Riparian
Tamarix ramosissima	Tamarisk, Salt cedar	Tamaricaceae	
Tamarix ramosissima	Tamarisk	Tamaricaceae	Fossil Creek Upland
Taraxacum officinale	Common dandelion	Asteraceae	Fossil Springs Riparian
Taraxacum officinale	Common dandelion	Asteraceae	Fossil Creek Riparian-East Bank-Spring
Taraxacum officinale	Common dandelion	Asteraceae	Fossil Creek Riparian
Taraxacum officinale	Common dandelion	Asteraceae	Fossil Springs Botanical Area
Thalictrum fendleri	Meadow rue	Ranunculaceae	Fossil Springs Botanical Area
Thalictrum fendleri	Meadow rue	Ranunculaceae	Fossil Creek Riparian
Thalictrum sp.	Meadow rue	Ranunculaceae	Fossil Creek Riparian
Thermopsis rhombifolia	Goldenpea	Fabaceae	Fossil Springs Botanical Area
Toxicodendron radicans	Poison ivy	Anacardiaceae	Fossil Springs Riparian
Toxicodendron radicans	Poison ivy	Anacardiaceae	Fossil Creek Riparian-Spring 13
Toxicodendron radicans	Poison ivy	Anacardiaceae	Fossil Creek Riparian-East Bank-Spring
Toxicodendron radicans	Poison ivy	Anacardiaceae	Fossil Creek Riparian
Tragia ramosa	Noseburn	Euphorbiaceae	Fossil Springs Botanical Area
Tragopogon dubius	Western salsify	Asteraceae	
Tragopogon dubius	Western salsify	Asteraceae	Fossil Creek Upland
Tridens sp.	Grass	Poaceae	Fossil Creek Riparian
Trifolium sp.	Clover	Fabaceae	Fossil Springs Botanical Area
Trifolium stellatum	Clover	Fabaceae	Fossil Creek Riparian
Typha domingensis	Cattail	Typhaceae	Fossil Springs Riparian
Typha domingensis	Cattail	Typhaceae	Fossil Springs Botanical Area
Typha domingensis	Cattail	Typhaceae	Fossil Creek Riparian
Typha domingensis	Cattail	Typhaceae	Fossil Creek Upland
Typha latifolia	Cattail	Typhaceae	Fossil Creek Riparian
Typha sp.	Cattail	Typhaceae	Fossil Creek Riparian-Spring 15
Typha sp.	Cattail	Typhaceae	Fossil Creek Riparian
Typha sp.	Cattail	Typhaceae	Fossil Springs Riparian
Ulmus pumila	Siberian elm	Ulmaceae	
Verbascum thapsus	Mullein	Scrophulariaceae	Fossil Springs Botanical Area

Verbascum thapsus	Mullein	Scrophulariaceae	Fossil Springs Riparian
Verbascum thapsus	Mullein	Scrophulariaceae	Fossil Creek Upland
Verbascum thapsus	Mullein	Scrophulariaceae	Fossil Creek Riparian-Spring 28
Verbena gooddinggii	Goodding vervain	Verbenaceae	Fossil Creek Upland
Verbena neomexicana	Vervain	Verbenaceae	Fossil Springs Botanical Area
Verbena neomexicana	Vervain	Verbenaceae	Fossil Creek Upland
Vinca major	Greater periwinkle	Apocynaceae	
Viola nephrophylla	Meadow violet	Violaceae	Fossil Springs Botanical Area
Vitis arizonica	Canyon grape	Vitaceae	Fossil Springs Botanical Area
Vitis arizonica	Canyon grape	Vitaceae	Fossil Creek Riparian-East Bank-Spring
Vitis arizonica	Canyon grape	Vitaceae	Fossil Creek Riparian-Spring
Vitis arizonica	Canyon grape	Vitaceae	Fossil Springs Riparian
Vitis arizonica	Canyon grape	Vitaceae	Fossil Creek Riparian-Spring 19
Vitis arizonica	Canyon grape	Vitaceae	Fossil Creek Upland
Vitis arizonica	Canyon grape	Vitaceae	Fossil Creek Riparian
Vitis arizonica	Canyon grape	Vitaceae	Fossil Creek Riparian-Spring 24
Vitis arizonica	Canyon grape	Vitaceae	Fossil Creek Riparian-Spring 25
Yucca angustissima	Narrowleaf Yucca	Agavaceae	Fossil Springs Botanical Area
Yucca baccata	Banana yucca	Agavaceae	Fossil Springs Botanical Area
Yucca baccata var. baccata	Banana yucca	Agavaceae	Fossil Creek Upland
Yucca sp.	Yucca	Agavaceae	Fossil Creek Riparian
Ziziphus obtusifolia	Gray thorn	Rhamnaceae	Fossil Creek Upland
Ziziphus obtusifolia	Gray thorn	Rhamnaceae	Fossil Springs Botanical Area

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APPENDIX B: BIRD SPECIES OBSERVED IN FOSSIL CREEK, LOCATION, AND OBSERVER (From Red Rock Ranger District Database [compiled 2003])

Observation Type	Common Name	Observation Location	Behavior	Observer
Actual	Acorn woodpecker	Stehr Lake		AZ Public Service Co.
Actual	American coot	Stehr Lake		NAAS
Actual	American goldfinch	Fossil Creek Riparian		AZ Public Service Co.
Actual	American Goldfinch	Riparian	Singing male	Taylor
Actual	American goldfinch	Stehr Lake		AZ Public Service Co.
Actual	Anna's hummingbird	Fossil Springs Riparian		NAAS
Actual	Ash-throated flycatcher	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Ash-throated flycatcher	Fossil Creek Riparian		E.L.Smith
Actual	Ash-throated flycatcher	Riparian & uplands	Singing male	Taylor
Actual	Ash-throated flycatcher	RNA and vicinity		Smith/Bender
Actual	Ash-throated flycatcher	Stehr Lake	singing	Agyagos
Actual	Ash-throated woodpecker	Riparian & uplands		AGFD
Actual	Audobon's warbler	Fossil Creek Riparian		AZ Public Service Co.
Actual	Bell's vireo			NAAS
Actual	Bell's Vireo	Aqueduct Spring		Agyagos
Actual	Bell's vireo	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Bell's vireo	Fossil Creek Riparian		E.L.Smith
Actual	Bell's Vireo	Fossil Creek Riparian		Agyagos

Actual	Bell's vireo	Fossil Springs Riparian	Agyagos	
Actual	Bell's vireo	Irving to bridge		Scott Bailey
Actual	Bell's Vireo	Not specified		AGFD
Actual	Bell's Vireo	Riparian & uplands	Singing male	Taylor
Actual	Bell's Vireo	RNA and vicinity		Smith/Bender
Actual	Bell's vireo	Stehr Lake	singing	Agyagos
Actual	Belted kingfisher	Fossil Creek Riparian		E.L.Smith
Actual	Belted kingfisher	Fossil Creek Riparian		AZ Public Service Co.
Actual	Belted kingfisher	Fossil springs		Bill Burbridge
Actual	Belted kingfisher	Fossil Springs Riparian-below dam		NAAS
Actual	Belted Kingfisher	RNA and vicinity		Smith/Bender
Actual	Bewick's wren	Fossil Creek Riparian		AZ Public Service Co.
Actual	Bewick's wren	Fossil Creek Riparian		E.L.Smith
Actual	Bewick's Wren	Fossil Springs Riparian		Agyagos
Actual	Bewick's wren	Fossil Springs Riparian		NAAS
Actual	Bewick's wren	Riparian & uplands	carrying food	AGFD
Actual	Bewick's Wren	RNA and vicinity		Smith/Bender
Actual	Bewick's wren	Stehr Lake	singing	Agyagos
Actual	Black Phoebe	Child's Powerplant		Overby, Agyagos
Actual	Black phoebe	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Black phoebe	Fossil Creek Riparian		AZ Public Service Co.
Actual	Black phoebe	Fossil Creek Riparian		E.L.Smith
Actual	Black phoebe	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Black phoebe	Fossil springs		Bill Burbridge

Actual	Black phoebe	Fossil Springs Riparian		Agyagos
Actual	Black phoebe	Fossil Springs Riparian		NAAS
Actual	Black Phoebe	Fossil/Verde Confluence		Sullivan
Actual	Black phoebe	Irving to bridge		Scott Bailey
Actual	Black phoebe	Riparian		Taylor
Actual	Black Phoebe	RNA and vicinity		Smith/Bender
Actual	Black phoebe	Stehr Lake		Agyagos
Actual	Black phoebe	Stehr Lake		AZ Public Service Co.
Actual	Black-chinned hummingbird	Fossil Creek Riparian		E.L.Smith
Actual	Black-chinned hummingbird	Fossil Springs Riparian		Agyagos
Actual	Black-chinned hummingbird	Not specified	singing male	Taylor
Actual	Black-chinned hummingbird	Riparian	nest with eggs	AGFD
Actual	Black-chinned hummingbird	RNA and vicinity		Smith/Bender
Actual	black-chinned hummingbird	Stehr Lake	male	Agyagos
Actual	Black-chinned sparrow	Flume Rd, 1 mile above Irving		NAAS
Actual	Black-chinned sparrow	Uplands		AGFD
Actual	Black-headed grosbeak	Fossil Creek Riparian		E.L.Smith
Actual	Black-headed grosbeak	Irving to bridge		Scott Bailey
Actual	Black-headed grosbeak	Riparian	fledged young present	AGFD
Actual	Black-headed grosbeak	Riparian	Singing male	Taylor
Actual	Black-headed grosbeak	RNA and vicinity		Smith/Bender
Actual	Black-headed grosbeak	Stehr Lake		AZ Public Service Co.
Actual	Black-throated gray warbler	Uplands	Singing male	Taylor
Actual	Black-throated sparrow	Fossil Creek Upland		Overby, Agyagos

Actual	Black-throated sparrow	Uplands	Singing male	Taylor
Actual	Black-throated sparrow	Uplands		AGFD
Actual	Blue grosbeak	Riparian	Nest building	Taylor
Actual	blue grosbeak	Stehr Lake	male	Agyagos
Actual	Blue-gray gnatcatcher	Irving Powerplant		NAAS
Actual	Blue-gray gnatcatcher	Riparian & uplands	Singing male	Taylor
Actual	Blue-gray Gnatcatcher	Uplands	nest with eggs	AGFD
Actual	Boat-tailed grackle	Stehr Lake		AZ Public Service Co.
Actual	Bridled titmouse	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Bridled titmouse	Fossil Creek Riparian		E.L.Smith
Actual	Bridled titmouse	Fossil Creek Riparian		AZ Public Service Co.
Actual	Bridled titmouse	Fossil Springs Riparian		NAAS
Actual	Bridled titmouse	RNA and vicinity		Smith/Bender
Actual	Broad-tailed hummingbird	Riparian & uplands	Singing male	Taylor
Actual	Bronzed cowbird	Riparian	Singing male	Taylor
Actual	Brown Creeper	Fossil springs		Bill Burbridge
Actual	Brown-crested flycatcher	Fossil Springs Riparian		NAAS
Actual	Brown-headed cowbird	Irving Powerplant		NAAS
Actual	Brown-headed cowbird	Irving to bridge		Scott Bailey
Actual	Brown-headed cowbird	Riparian	singing male	Taylor
Actual	Brown-headed cowbird	Riparian & uplands	pair	AGFD
Actual	Bushtit	Irving Powerplant-trailhead		NAAS
Actual	Bushtit	Riparian & uplands	fledged young present	AGFD
Actual	Bushtit	Uplands		Taylor

Actual	Cactus wren	Stehr Lake		NAAS
Actual	Cactus wren	Uplands		AGFD
Actual	Canyon towhee	Child's Powerplant		Overby, Agyagos
Actual	Canyon towhee	Uplands	courtship	AGFD
Actual	Canyon wren	Above springs		NAAS
Actual	Canyon wren	Fossil Creek Riparian		E.L.Smith
Actual	Canyon wren	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Canyon Wren	Fossil Springs Riparian		Agyagos
Actual	Canyon wren	Fossil/Verde Confluence		Sullivan
Actual	Canyon wren	Riparian & uplands	probable nest site	AGFD
Actual	Canyon wren	Riparian & uplands	Singing male	Taylor
Actual	Canyon Wren	RNA and vicinity	Smith/Bender	
Actual	Cassin's kingbird	Fossil Creek Riparian		E.L.Smith
Actual	Cassin's kingbird	Irving Powerplant		NAAS
Actual	Cassin's kingbird	Riparian & uplands	fledged young present	AGFD
Actual	Cassin's kingbird	RNA and vicinity		Smith/Bender
Actual	Chipping Sparrow	Uplands	pair	Taylor
Actual	Common blackhawk	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Common blackhawk	Fossil Springs Riparian		NAAS
Actual	Common Blackhawk	Fossil Springs Riparian		Agyagos
Actual	Common blackhawk	Irving Powerplant		NAAS
Actual	Common blackhawk	Irving to bridge		Scott Bailey
Actual	Common blackhawk	Uplands		Taylor
Actual	Common black-hawk	Fossil Creek Riparian		AZ Public Service Co.
Actual	Common Raven	Aqueduct Spring		Agyagos

Actual	Common raven	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Common raven	Fossil Creek Riparian		E.L.Smith
Actual	Common raven	Fossil Creek Riparian		AZ Public Service Co.
Actual	Common raven	Fossil Creek Upland		Overby, Agyagos
Actual	Common Raven	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Common raven	Irving Powerplant		NAAS
Actual Taylor	Common raven	Riparian & uplands		AGFD ctual Common Raven Riparian & Uplands
Actual	Common raven	RNA and vicinity		Smith/Bender
Actual	Common raven	Stehr Lake		AZ Public Service Co.
Actual	Common yellowthroat	Fossil Creek Riparian		E.L.Smith
Actual	Common Yellowthroat	Stehr Lake	singing	Groschupf, McKinstry
Actual	Common Yellowthroat	Stehr Lake	2 males	Groschupf, McKinstry
Actual	Common yellowthroat	Stehr Lake	singing male	Agyagos
Actual	Common yellow-throat	RNA and vicinity		Smith/Bender
Actual	Cooper's hawk	Not specified		AGFD
Actual	Cooper's hawk	Riparian	nest with young	Taylor
Actual	Cooper's hawk	Stehr Lake	Adult female and immature	Robert Magill- AGFD
Actual	Cordilleran flycatcher	Fossil Springs Riparian		NAAS
Actual	Costa's hummingbird	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Costa's hummingbird	Strawberry SW Block		AGFD
Actual	Crissal thrasher	Riparian	pair	AGFD
Actual	Dark-eyed junco	Child's Powerplant	numerous	Overby, Agyagos
Actual	Eared grebe	Stehr Lake		AZ Public Service Co.
Actual	Gambel's quail	Fossil - Bridge to Boulder Canyon		Scott Bailey

Actual	Gambel's quail	Irving Powerplant-3 miles below		NAAS
Actual	Gambel's Quail	Not specified		AGFD
Actual	Gambel's Quail	Stehr Lake	females, males, babies	Agyagos
Actual	Gambel's quail	Stehr Lake		AZ Public Service Co.
Actual	Gambel's quail	Uplands	Pair	Taylor
Actual	Gamble's Quail	Child's Powerplant		Robert Magill- AGFD
Actual	Gila woodpecker	Child's Powerplant		Overby, Agyagos
Actual	Gila woodpecker	Fossil Creek Riparian		E.L.Smith
Actual	Gila woodpecker	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Gila woodpecker	Riparian		AGFD
Actual	Gila Woodpecker	RNA and vicinity		Smith/Bender
Actual	Gila woodpecker	Uplands		Taylor
Actual	golden eagle	Child's Powerplant	Immature	Robert Magill- AGFD
Actual	Golden eagle	Irving Powerplant		NAAS
Actual	gray flycatcher	Child's Powerplant		Robert Magill- AGFD
Actual	Gray flycatcher	Riparian	Singing male	Taylor
Actual	Gray flycatcher	Uplands		AGFD
Actual	Gray vireo	Uplands		AGFD
Actual	Gray vireo	Uplands	Singing male	Taylor
Actual	Gray-headed junco	Fossil springs		Bill Burbridge
Actual	Great blue heron	Child's Powerplant	pair	Overby, Agyagos
Actual	Great blue heron	Fossil Creek Riparian		E.L.Smith
Actual	Great blue heron	Fossil Creek Riparian		AZ Public Service Co.
Actual	Great blue heron	Fossil/Verde Confluence		Sullivan
Actual	Great Blue Heron	RNA and vicinity	Smith/Bender	

Actual	Great blue heron	Stehr Lake		AZ Public Service Co.
Actual	Greater roadrunner	Uplands		Taylor
Actual	Great-horned owl	Uplands	Singing male	Taylor
Actual	Great-tailed grackle	Child's Powerplant	numeous males and females	Overby, Agyagos
Actual	Great-tailed grackle	Irving Powerplant		NAAS
Actual	Great-tailed grackle	Stehr Lake	males and females	Agyagos
Actual	Great-tailed grackles	Stehr Lake	flock of 20	Groschupf, McKinstry
Actual	Great-tailed grackles	Stehr Lake	flock of 20	Groschupf, McKinstry
Actual	Green-tailed towhee	Uplands		Taylor
Actual	Hairy Woodpecker	Fossil springs		Bill Burbridge
Actual	Hairy woodpecker	Fossil Springs Riparian		NAAS
Actual	Hermit thrush	Fossil Creek Riparian		E.L.Smith
Actual	Hermit thrush	RNA and vicinity		Smith/Bender
Actual	hooded oriole	Child's Powerplant		Robert Magill- AGFD
Actual	Hooded Oriole	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Hooded oriole	Fossil Creek Riparian		E.L.Smith
Actual	Hooded oriole	Fossil Creek Riparian		AZ Public Service Co.
Actual	Hooded oriole	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Hooded oriole	Irving Powerplant		NAAS
Actual	Hooded oriole	Irving to bridge		Scott Bailey
Actual	Hooded oriole	Riparian	carrying food	AGFD
Actual	Hooded Oriole	Riparian	Territory	Taylor
Actual	Hooded Oriole	RNA and vicinity		Smith/Bender
Actual	Hooded oriole	Stehr Lake		AZ Public Service Co.

Actual	Hooed oriole	Stehr Lake	1 singing male, 2 females	Agyagos
Actual	House finch	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	House finch	Fossil Creek Riparian		E.L.Smith
Actual	House finch	Fossil Creek Riparian		AZ Public Service Co.
Actual	House finch	Riparian & uplands		AGFD
Actual	House finch	RNA and vicinity		Smith/Bender
Actual	House finch	Stehr Lake		AZ Public Service Co.
Actual	Hutton's vireo	Not specified		AGFD
Actual	Hutton's vireo	Riparian	Pair	Taylor
Actual	Indigo bunting	Stehr Lake	singing	Agyagos
Actual	killdeer	Child's Powerplant		Robert Magill- AGFD
Actual	Ladder backed woodpecker	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Ladder-backed woodpecker	Fossil Springs Riparian		NAAS
Actual	Ladder-backed woodpecker	Not specified		AGFD
Actual	Ladder-backed woodpecker	Riparian & uplands	Singing male	Taylor
Actual	Lark Sparrow	Uplands	pair	Taylor
Actual	Lazuli bunting	Fossil Springs Riparian		NAAS
Actual	Lazuli bunting	Riparian	AGFD	
Actual	Le Conte's thrasher	Riparian & uplands		Taylor
Actual	Lesser goldfinch	Fossil Creek Riparian		E.L.Smith
Actual	Lesser goldfinch	Irving Powerplant		NAAS
Actual	Lesser goldfinch	Irving to bridge		Scott Bailey
Actual	Lesser goldfinch	Riparian		AGFD
Actual	Lesser goldfinch	RNA and vicinity		Smith/Bender
Actual	Lesser goldfinch	Stehr Lake	male	Agyagos

Actual	Loggerhead shrike	Fossil Creek Riparian		E.L.Smith
Actual	Loggerhead shrike	RNA and vicinity		Smith/Bender
Actual	Lucy's warbler	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Lucy's warbler	Fossil Creek Riparian		Agyagos
Actual	Lucy's warbler	Fossil Springs Riparian		AZ Public Service Co.
Actual	Lucy's warbler	Fossil Springs Riparian		NAAS
Actual	MacGillivray's warbler	Fossil Creek Riparian		E.L.Smith
Actual	MacGillivray's Warbler	RNA and vicinity		Smith/Bender
Actual	Magnificient hummingbird	Uplands	Singing male	Taylor
Actual	Mallard	Stehr Lake		AZ Public Service Co.
Actual	Mexican Jay	Riparian		Taylor
Actual	Mockingbird	Fossil Creek Riparian		AZ Public Service Co.
Actual	Mockingbird	Fossil Creek Riparian		E.L.Smith
Actual	Mockingbird	RNA and vicinity	Smith/Bender	
Actual	Mockingbird	Stehr Lake		AZ Public Service Co.
Actual	Mourning dove	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Mourning dove	Fossil Creek Riparian		AZ Public Service Co.
Actual	Mourning dove	Irving to bridge		Scott Bailey
Actual	Mourning dove	Many locations		NAAS
Actual	Mourning dove	Not specified		AGFD
Actual	Mourning dove	Riparian & uplands	Singing male	Taylor
Actual	Mourning dove	Stehr Lake		AZ Public Service Co.
Actual	Mourning dove	Stehr Lake		Agyagos
Actual	northern cardinal	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Northern cardinal	Fossil Creek Riparian	Pair	Agyagos

Actual	Northern cardinal	Riparian	Pair	Taylor
Actual	Northern cardinal	Riparian & uplands		AGFD
Actual	Northern cardinal	Stehr Lake	2 males	Agyagos
Actual	Northern flicker	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Northern flicker	Riparian & uplands	On nest	Taylor
Actual	Northern flicker	Stehr Lake		AZ Public Service Co.
Actual	northern flicker	Stehr Lake		Agyagos
Actual	Northern mockingbird	Child's Powerplant		Overby, Agyagos
Actual	Northern mockingbird	Stehr Lake		NAAS
Actual	Northern mockingbird	uplands	On nest	Taylor
Actual	Northern oriole	Fossil Creek Riparian		AZ Public Service Co.
Actual	Northern oriole	Riparian		AGFD
Actual	Northern oriole	Stehr Lake	male	Agyagos
Actual	Northern rough-winged swallow			Irving Powerplant NAAS
Actual	Northern saw-whet owl	Fossil Springs Riparian	Feeding on bird	Agyagos
Actual	Nothern cardinal	Irving to bridge		Scott Bailey
Actual	Olive-sided flycatcher	Fossil Creek Riparian		E.L.Smith
Actual	Olive-sided flycatcher	Fossil Creek Riparian		AZ Public Service Co.
Actual	Olive-sided flycatcher	RNA and vicinity		Smith/Bender
Actual	Peregrine falcon	Fossil Creek Riparian		E.L.Smith
Actual	Peregrine Falcon	RNA and vicinity		Smith/Bender
Actual	Phainopepela	Fossil Creek Riparian		Agyagos
Actual	Phainopepla	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Phainopepla	Fossil Creek/Spring		Robert Magill- AGFD

Actual	Phainopepla	Fossil Springs Riparian		Agyagos
Actual	Phainopepla	Irving to bridge		Scott Bailey
Actual	Phainopepla	Many locations		NAAS
Actual	Phainopepla	Riparian & uplands	Fledged young present	Taylor
Actual	Phainopepla	Stehr Lake	lots	Agyagos
Actual	Plain Titmouse	Not specified		AGFD
Actual	Plain titmouse	Uplands		Taylor
Actual	Pyrrhuloxia	Child's Powerplant		Robert Magill- AGFD
Actual	Red-shafted flicker	Fossil Creek Riparian		E.L.Smith
Actual	Red-shafted flicker	RNA and vicinity		Smith/Bender
Actual	Red-tailed hawk	Fossil Creek Riparian		AZ Public Service Co.
Actual	Red-tailed hawk	Fossil Creek Upland		Overby, Agyagos
Actual	Red-tailed hawk	Irving Powerplant		NAAS
Actual	Red-tailed hawk	Stehr Lake		AZ Public Service Co.
Actual	Red-tailed hawk	Uplands		AGFD
Actual	red-tailed hawk	Uplands		Taylor
Actual	Red-winged blackbird	Child's Powerplant		Overby, Agyagos
Actual	Red-winged blackbird	Stehr Lake		AZ Public Service Co.
Actual	Red-winged blackbirds	Stehr Lake	five	Groschupf, McKinstry
Actual	Robin	Fossil springs		Bill Burbridge
Actual	Rough-legged hawk	Fossil Creek Riparian		E.L.Smith
Actual	Rough-legged hawk	RNA and vicinity		Smith/Bender
Actual	Ruby-crowned kinglet	Child's Powerplant		Overby, Agyagos
Actual	Rufous hummingbird	Fossil Creek Riparian		AZ Public Service Co.
Actual	rufous-crowned sparrow	Not specified		AGFD

Actual	Rufous-crowned sparrow	Uplands	Singing male	Taylor
Actual	Rufous-sided towhee	Fossil Creek Riparian		AZ Public Service Co.
Actual	Rufous-sided towhee	Uplands	Territory	Taylor
Actual	Say's phoebe	Stehr Lake		Agyagos
Actual	Scott's oriole	Fossil Creek Riparian		E.L.Smith
Actual	Scott's oriole	Irving Powerplant		NAAS
Actual	Scott's Oriole	RNA and vicinity		Smith/Bender
Actual	Scrub jay	Fossil Creek Riparian		E.L.Smith
Actual	Scrub jay	Riparian	fledged young present	AGFD
Actual	Scrub jay	RNA and vicinity		Smith/Bender
Actual	Scrub jay	Uplands		Taylor
Actual	Solitary vireo	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Solitary vireo	Fossil Creek Riparian		E.L.Smith
Actual	Solitary vireo	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Solitary vireo	Fossil Springs Riparian		NAAS
Actual	Solitary vireo	Irving to bridge		Scott Bailey
Actual	Solitary Vireo	RNA and vicinity		Smith/Bender
Actual	Song sparrow	Fossil Creek Riparian		AZ Public Service Co.
Actual	Song Sparrow	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Song sparrow	Strawberry SW Block		AGFD
Actual	Sparrow hawk	Fossil Creek Riparian		E.L.Smith
Actual	Sparrow hawk	RNA and vicinity		Smith/Bender
Actual	Sparrow sp	Child's Powerplant		Overby, Agyagos
Actual	Spotted towhee	Fossil Springs Riparian		NAAS
Actual	Spotted towhee	Irving Powerplant		NAAS

Actual	Starling	Child's Powerplant	numerous	Overby, Agyagos
Actual	Sulphur-bellied flycatcher	Strawberry SW Block	singing	AGFD
Actual	Summer tanager	Child's Powerplant		Robert Magill- AGFD
Actual	Summer tanager	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Summer tanager	Fossil Creek Riparian		AZ Public Service Co.
Actual	Summer tanager	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Summer tanager	Fossil Springs Riparian		NAAS
Actual	Summer tanager	Not specified	carrying food	AGFD
Actual	Summer tanager	Riparian	Pair	Taylor
Actual	Summer tanager	Stehr Lake	male	Agyagos
Actual	Turkey vulture	Along length of canyon		NAAS
Actual	Turkey vulture	Fossil Creek Riparian		AZ Public Service Co.
Actual	Turkey vulture	Fossil Creek Riparian		E.L.Smith
Actual	Turkey vulture	Fossil Creek Upland		Overby, Agyagos
Actual	Turkey vulture	Riparian & uplands		AGFD
Actual	Turkey Vulture	RNA and vicinity		Smith/Bender
Actual	Turkey vulture	Stehr Lake		AZ Public Service Co.
Actual	Turkey Vulture	Uplands		Taylor
Actual fledged young present	Verdin AGFD	Child's Powerplant	pair	Overby, AgyagosActual Verdin Riparian & uplands
Actual	Verdin	Uplands	Singing male	Taylor
Actual	Vermillion flycatcher	Fossil/Verde Confluence		Sullivan
Actual	Violet-green swallow	All locations		NAAS
Actual	Violet-green swallow	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Violet-green swallow	Fossil Creek Riparian		AZ Public Service Co.

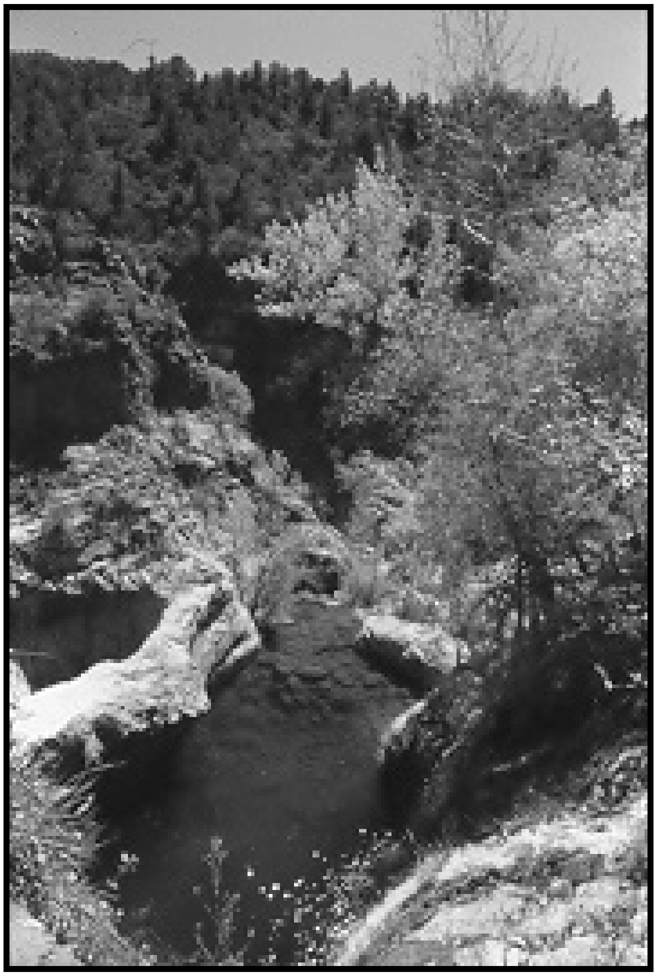
Actual	Violet-green swallow	Fossil Springs Riparian		Agyagos
Actual	Violet-green swallow	Irving to bridge		Scott Bailey
Actual	Violet-green swallow	Not specified		AGFD
Actual	Violet-green swallow	Riparian & uplands		Taylor
Actual	Violet-green swallow	Stehr Lake		AZ Public Service Co.
Actual	Vireo sp	Child's Powerplant		Overby, Agyagos
Actual	Virginia's warbler	Fossil Creek Riparian		AZ Public Service Co.
Actual	Virginia's warbler	Fossil Creek Riparian		E.L.Smith
Actual	Virginia's warbler	Fossil Springs Riparian		NAAS
Actual	Virginia's Warbler	RNA and vicinity		Smith/Bender
Actual	Virginina's warbler	Riparian	Singing male	Taylor
Actual	Warbling vireo	Fossil Creek Riparian		E.L.Smith
Actual	Warbling vireo	Fossil Springs Riparian		AZ Public Service Co.
Actual	Warbling Vireo	RNA and vicinity		Smith/Bender
Actual	Weid's Crested flycatcher	RNA and vicinity		Smith/Bender
Actual	Western bluebird	Child's Powerplant	2	Overby, Agyagos
Actual	Western kingbird	Fossil Creek Riparian		AZ Public Service Co.
Actual	Western kingbird	Irving to bridge		Scott Bailey
Actual	Western kingbird	Riparian	Singing male	Taylor
Actual	Western kingbird	Stehr Lake		AZ Public Service Co.
Actual	Western meadowlark	Uplands	Singing male	Taylor
Actual	Western tanager	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Western tanager	Fossil Creek Riparian		AZ Public Service Co.
Actual	Western Tanager	Fossil Creek/Spring		Robert Magill- AGFD

Actual	Western tanager	Riparian	Singing male	Taylor
Actual	Western tanager	Stehr Lake		AZ Public Service Co.
Actual	Western wood pewee	Fossil Creek Riparian		AZ Public Service Co.
Actual	Western wood pewee	Fossil Creek Riparian		Agyagos
Actual	Western wood pewee	Fossil Creek Riparian		E.L.Smith
Actual	Western wood pewee	Fossil Springs Riparian		Agyagos
Actual	Western wood pewee	Irving to bridge		Scott Bailey
Actual	Western wood pewee	Riparian	Singing male	Taylor
Actual	Western Wood Pewee	RNA and vicinity		Smith/Bender
Actual	Western wood-pewee	Not specified		AGFD
Actual	White-crowned sparrow	Uplands	singing male	Taylor
Actual	White-throated swift	Fossil Creek/Spring		Robert Magill- AGFD
Actual	White-throated swift	Not specified		AGFD
Actual	White-throated swift	Riparian		Taylor
Actual	White-winged dove	Fossil Creek/Spring		Robert Magill- AGFD
Actual	White-winged dove	Riparian		AGFD
Actual	Wied's crested flycatcher	Fossil Creek Riparian		E.L.Smith
Actual	Wilson Warbler	Riparian	Pair	Taylor
Actual	Yellow warbler	Child's Powerplant	Pair	Robert Magill- AGFD
Actual	Yellow warbler	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Yellow warbler	Fossil Creek Riparian		AZ Public Service Co.
Actual	Yellow warbler	Fossil Creek Riparian		E.L.Smith
Actual	Yellow warbler	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Yellow warbler	Fossil Springs Riparian		Agyagos
Actual	Yellow warbler	Fossil Springs Riparian		NAAS

Actual	Yellow warbler	Fossil/Verde Confluence		Sullivan
Actual	Yellow warbler	Irving Powerplant		NAAS
Actual	Yellow warbler	Irving to bridge		Scott Bailey
Actual	Yellow warbler	Not specified		AGFD
Actual	Yellow warbler	Riparian	Pair	Taylor
Actual	Yellow warbler	RNA and vicinity		Smith/Bender
Actual	Yellow Warbler	Stehr Lake		Robert Magill- AGFD
Actual	Yellow warbler	Stehr Lake	singing	Agyagos
Actual	Yellow-bellied sapsucker	Fossil Creek Riparian	AZ Public Service Co.	
Actual	Yellow-billed cuckoo	Riparian		Taylor
Actual	Yellow-breasted chat	Aqueduct Spring		Agyagos
Actual	yellow-breasted chat	Fossil - Bridge to Boulder Canyon		Scott Bailey
Actual	Yellow-breasted chat	Fossil Creek Riparian		E.L.Smith
Actual	Yellow-breasted chat	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Yellow-breasted chat	Fossil Springs Riparian		Agyagos
Actual	Yellow-breasted chat	Riparian	Singing male	Taylor
Actual	Yellow-breasted chat	RNA and vicinity		Smith/Bender
Actual	yellow-breasted chat	Stehr Lake	singing	Agyagos
Actual	Yellow-rumped warbler	Fossil/Verde Confluence		Sullivan
Actual	Zone-tailed hawk	Fossil Creek/Spring		Robert Magill- AGFD
Actual	Zone-tailed hawk	Not specified		AGFD
Actual	Zone-tailed hawk	Uplands		Taylor

Appendix C. Recreation

Fossil Creek Visitor Survey



NORTHERN ARIZONA UNIVERSITY FORESTRY

NORTHERN ARIZONA UNIVERSITY

SCHOOL OF FORESTRY

Dear Fossil Creek Visitor:

Thanks for agreeing to share your opinions about this special area. The questions in this booklet relate to your visit to Fossil Creek when you were contacted by an interviewer and given the survey packet.

This is your opportunity to help direct the future management of Fossil Creek. You are one of a small number of visitors who are being asked to give their opinions about this area. Information from this survey will help recreation managers better manage recreation use on Fossil Creek and provide the type of recreation that best meets visitors' needs while protecting this very special resource.

It should take you about 15-20 minutes to complete the questionnaire. There are no right or wrong answers and your responses will remain confidential. When you have finished the questionnaire, please return it to us in the enclosed postage-paid envelope.

If you have any questions or comments about this survey, please feel free to contact me, the study director:

Dr. Marty Lee
School of Forestry
Box 15018
Northern Arizona University
Flagstaff, AZ 86011
(928) 523-6644
martha.lee@nau.edu

Thank you again for your help!

Sincerely,

Marty Lee
Project Manager

Cover photo taken by Sylvester Allred

Section I. Your Visit to Fossil Creek

1. What type of group are you with? (check one)

____alone
____ family
____ friends
____ family and friends
____ school group
____ other (please describe) ___________________________

2. How many people in your group (including yourself) are in the following age classes?

____ Children (5and under)
____ Youth (6-17 years old)
____ Adult (18-61 years old)
____ Senior (62+ years old)

____TOTAL Group Size

3. How long was your visit to Fossil Creek? (check one)

____2 hours or less
____between 2 and 6 hours (1/2 day)
____between 6-12 hours (1 day)
____more than 1 day → How many days? _______days

4. How did you access the Fossil Creek area? (check one)

____ from Strawberry
____ from the Verde Valley

5. People have many reasons for visiting national forests. A number of these reasons are listed below. Circle the number that best describes the importance of each of the following reasons for why you visited Fossil Creek.

	Extremely Important	**Somewhat Important**	**Not Important**
To enjoy the sounds and smells of nature	3	2	1
To feel isolated	3	2	1
To see the dam	3	2	1
To see Fossil Creek	3	2	1
To relieve stress and tension	3	2	1
To bring back pleasant memories	3	2	1
To be with family or friends	3	2	1
To be with people who enjoy the same things I do	3	2	1
To exercise and improve my physical fitness	3	2	1
To view the scenery	3	2	1
To party	3	2	1
To do something creative such as sketch, paint, take photographs	3	2	1
To take risks	3	2	1
To experience a cooler temperature	3	2	1
To experience tranquility	3	2	1
To rest and relax	3	2	1
To camp and have a fire	3	2	1
To go swimming	3	2	1
To hike/backpack	3	2	1
To show visiting friends and relatives	3	2	1
Just curious to see what was here	3	2	1
To experience solitude	3	2	1
To wade in the creek	3	2	1
To get away from the usual demands of life	3	2	1
To visit the Verde Hot Springs	3	2	1

Please list any additional reasons not included in the list above that had a strong influence on your decision to come to Fossil Creek.

____

____

____

6. In which of the following activities did you participate during your visit to Fossil Creek? (check all that apply)

____ Sightseeing
____ Swimming
____ Rock collecting/prospecting
____ Picnicking
____ Driving for pleasure
____ Watching wildlife
____ Camping near vehicle
____ Walking
____ Viewing Indian ruins
____ Target shooting
____ Photography
____ Writing for pleasure
____ Fishing
____ Hot springing
____ Mountain biking
____ Backpack camping
____ Wading
____ Sunbathing
____ Mediation
____ Hiking (day use)
____ Horseback riding
____ Partying
____ Bird watching
____ Nature study
____ Reading for pleasure
____ Hunting
____ Fluming

7. Is this your first visit to Fossil Creek? (Check one)

____Yes → (If Yes) skip to question 8.

____ No → (If No) a. Would you call yourself a … (check one)

____ Frequent visitor (once a month or more)
____ Occasional visitor (visitor 2 or more times/year)
____ Annual visitor (once a year)
____ Infrequent visitor (less than once a year)

b. Since you have been coming to Fossil Creek, have you noticed any changes in recreation use or recreation impacts?

____ No

____ Yes → (If Yes) Please briefly describe:

____

____

____

8. In general, how crowded did you feel during your visit to Fossil Creek? (circle one number)

1	2	3	4	5	6	7	8	9
Not at all crowded		Slightly crowded			Moderately crowded			Extremely crowded

9. Activities designed to restore Fossil Creek to a more natural state are scheduled to begin in fall 2004. The non-native fish in Fossil Creek will be removed and a fish barrier installed to protect the native fish from competition from non-native fish. The Fossil Springs Diversion Dam is scheduled for removal by December 31, 2004 to restore a full flow of water to Fossil Creek.

How do you feel about:

a. the removal of non-native fish from Fossil Creek? (check one)

____ I support removal of non-native fish
____ I do not support removal of non-native fish
____ I do not feel strongly one way or another

b. the removal of the dam to restore full flow to Fossil Creek? (check one)

____ I support removal of the dam to restore full flows
____ I do not support removal of the dam to restore full flows
____ I do not feel strongly one way or another

10. Are you interested in being a member of a volunteer group ("Friends of Fossil Creek" for example) that would work with the Forest Service to manage and protect Fossil Creek? (check one)

____ No
____ Yes → (If Yes) Please put your name and address on a separate piece of paper and return it to us along with your questionnaire. We will give that information to the Forest Service

11. Map question

Section II. Managing Recreation Use of the Fossil Creek Area

12. Fossil Creek managers are interested in any problems you may have encountered during your visit in the place you marked on the map (Question 11). Circle the number that best describes how serious you found each to be.

	Not a problem	**Slight problem**	**Moderate problem**	**Serious problem**	**Very serious problem**
Litter on the roadside	1	2	3	4	5
Litter in camping areas	1	2	3	4	5
Litter near or in Fossil Creek	1	2	3	4	5
Vandalism	1	2	3	4	5
Too few rules and regulations	1	2	3	4	5
Unleashed dogs in the area	1	2	3	4	5
People shouting and yelling	1	2	3	4	5
Lack of law enforcement	1	2	3	4	5
Dogs with visitors	1	2	3	4	5
Lack of emergency contact information	1	2	3	4	5
Livestock in the area	1	2	3	4	5
Nudity	1	2	3	4	5
People being inconsiderate	1	2	3	4	5
Too few commercial establishments in the area	1	2	3	4	5
Off road vehicles in the area	1	2	3	4	5
Airplanes flying overhead	1	2	3	4	5
Vegetation damage	1	2	3	4	5
Cut tree limbs	1	2	3	4	5

13. Fossil Creek managers are interested in the types of information services you would find most useful for providing information about Fossil Creek. Which of the following ways of receiving information would you prefer? (check all that apply)

_____ on-site information kiosks or bulletin boards
_____ interacting with Forest Service staff on-site
_____ contacting Forest Service offices
_____ on the Forest Service website
_____ be on a Fossil Creek mailing list
_____ brochures, other information available on-site that I can take with me
_____ self-guided interpretative trails on-site

_____ I am not interested in receiving information about Fossil Creek

14. There are many kinds of services that Fossil Creek managers could provide to Fossil Creek visitors. Below is a list of facilities and services that could be provided at Fossil Creek.

Please indicate how important you think each would be in enhancing recreation on Fossil Creek (circle one number for each)

	Extremely important	**Somewhat important**	**Not important**	**Don't know**
Restroom facilities	3	2	1	DK
Drinking water	3	2	1	DK
Developed campgrounds	3	2	1	DK
Developed picnic areas	3	2	1	DK
Group campsites	3	2	1	DK
Group picnic (day use) areas	3	2	1	DK
Directional signs on the roads	3	2	1	DK
Directional signs on trails	3	2	1	DK
Having Forest Service personnel on-site	3	2	1	DK
Garbage cans at recreation sites	3	2	1	DK
Handicapped access to the creek	3	2	1	DK
Fishing opportunities	3	2	1	DK
Dispersed (undeveloped) campsites	3	2	1	DK
Designated dispersed campsites	3	2	1	DK
Historical interpretation of the Childs and Irving power plants	3	2	1	DK
A system of designated trails in the Fossil Creek area	3	2	1	DK

15. In order to protect Fossil Creek from significant recreation impacts, the Forest Service is considering making some changes in how they manage recreation use on Fossil Creek. We have divided the area into two sections—**Upper Fossil Creek** (from the Irving power plant upstream to and including Fossil Springs but excluding wilderness) and **Middle Fossil Creek** (Irving power plant downstream 2.9 miles to junction of Forest Roads 708 and 502).

Please indicate your level of support for each of the following potential actions by putting an “S” next to actions you would *support* and an “N” next to actions you would *not support*, and a “DK” next to locations you *don’t know if you could support*.

Upper Fossil Creek – Irving upstream

____allow day use only

____ prohibit campfires

____ construct a trail system between Fossil Springs and the current dam site

Middle Fossil Creek – Irving downstream 2.9 miles

____ continue to allow camping but only in designated dispersed (undeveloped) camping sites

____ move dispersed (undeveloped) camping away from the creek

____ limit vehicle access near the creek

____ construct a non-motorized trail along Fossil Creek between Irving and the junction of Forest Roads 708 and 502.

____ provide interpretative information on-site on the natural and cultural features of Fossil Creek

Section III. Visitor Information.

These last questions will help us learn about the people who participated in the study. All information is STRICTLY CONFIDENTIAL and WILL NOT be associated with you as an individual.

16. What is your home city and state?

City ________________________________ State ________________________

17. Gender (check one): _____ female _____ male

18. Which best describes your race or ethnic group? (check one)

____African American
____Asian
____Caucasian

____Hispanic
____Native American
____Pacific Islander
____Other

19. Which of the following **best** describes your current employment status? (check one)

____ full-time student
____ part-time student
____ unemployed
____ retired

____ employed full-time
____ employed part-time
____ full-time homemaker/caregiver
____ other (specify) ________________________

20. Is there anything else you would like to tell us about your visit to Fossil Creek area that was not covered in this survey?

Thank you very much for your valuable input. Please return the questionnaire in the enclosed postage paid envelope.

Visit Characteristics

Group Type (n=114)

Group Type	Percent
Alone	2
Family	23
Friends	24
Family and friends	22
School group	2
Other*	28

*Primarily Boy Scout groups

Where Visitors Spend the Most Time (n=102)

Fossil Creek Zone	Percent
Irving to Fossil Springs	52
Below Irving to and including FR 708 bridge	11
Below bridge to and including FR 708/502 junction	2
Below FR 708/502 junction to BM 3715	5
Below BM 3715 (Stehr Lake area)	19
Multiple areas above Irving	3
Multiple areas Irving to Stehr Lake	3
Multiple areas above and below Irving	6

Group Size (n=111)

Minimum: 1 person
Maximum: 40 people
Mean: 9 people

Length of Stay (n=117)

Length of Stay	Percent
2 hours or less	6
Between 2 and 6 hours	32
Between 6 and 12 hours	20
More than 1 day	42

Access to the Fossil Creek Area (n=114)

Access Fossil Creek:	Percent
From Strawberry	71
From the Verde Valley	29

First Visit to Fossil Creek (n=100)

First Visit?	Percent
Yes	38
No	62

Reasons for Visiting Fossil Creek (n=110-113)

Reason for Visiting Fossil Creek	Extremely important	Somewhat important	Not important
	- - - - - - - - - percent	- - - - - - - - -	
To enjoy the sounds and smells of nature	84	13	3
To feel isolated	41	46	12
To see the dam	15	29	56
To see Fossil Creek	76	22	2
To relieve stress and tension	60	33	7
To bring back pleasant memories	33	40	27
To be with family or friends	65	28	7
To be with people who enjoy the same things I do	56	32	12
To exercise and improve my physical fitness	40	43	17
To view the scenery	90	9	1
To party	6	18	76
To do something creative such as sketch, paint, take photographs	10	33	57
To take risks	6	13	81
To experience a cooler temperature	41	32	27
To experience tranquility	63	30	7
To rest and relax	56	31	13
To camp and have a fire	35	26	39
To go swimming	48	32	20
To hike/backpack	61	27	12
To show visiting friends and relatives	20	35	45
Just curious to see what was here	28	39	33
To experience solitude	36	41	23
To wade in the creek	49	33	19
To get away from the usual demands of life	68	25	7
To visit the Verde Hot Springs	13	27	60
To go fishing and/or hunting	14	16	69

Activities (n=114)

Activity	Percent*
Sightseeing	88
Swimming	70
Rock collecting/prospecting	11
Picnicking	48
Driving for pleasure	17
Watching wildlife	43
Camping near vehicle	31
Walking	72
Viewing Indian ruins	6
Target shooting	6
Photography	37
Writing for pleasure	4
Fishing	17
Hot springing	18
Mountain biking	2
Backpack camping	22
Wading	62
Sunbathing	25
Meditation	21
Hiking (day use)	60
Horseback riding	2
Partying	16
Bird watching	13
Nature study	18
Reading for pleasure	16
Hunting	3
Fluming	17

* Totals more than 100 percent due to multiple responses.

Management of Fossil Creek

Feelings About Removal of Non-Native Fish from Fossil Creek (n=117)

Feelings about Non-Native Fish Removal	Percent
Support removal of non-native fish	45
Do not support removal of non-native fish	16
Do not feel strongly one way or the other	39

Feelings About Removal of the Dam to Restore Full Flow to Fossil Creek (n=115)

Feelings About Dam Removal	Percent
Support removal of the dam to restore full flows	55
Do not support removal of the dam to restore full flows	30
I do not feel strongly one way or the other	16

Problems Visitors May Have Encountered (n=110-114)

Problems	Not a problem	Slight problem	Moderate problem	Serious problem	Very serious problem
	- - - - - - - - - - - - - - percent - - - - - - - - - - - - - - - - -				
Litter on the roadside	34	31	17	9	9
Litter in the camping area	19	22	23	16	20
Litter near or in Fossil Creek	24	32	22	11	11
Vandalism	58	22	12	5	3
Too few rules and regulations	76	6	11	2	4
Unleashed dogs in the area	75	12	6	4	3
People shouting and yelling	62	25	7	3	3
Lack of law enforcement	79	8	7	3	4
Dogs with visitors	82	10	4	3	1
Lack of emergency contact information	66	13	12	5	4
Livestock in the area	93	4	3	--	--
Nudity	94	4	1	1	--
People being inconsiderate	66	18	10	3	3
Too few commercial establishments in the area	94	4	1	1	--
Off road vehicles in the area	85	6	5	2	2
Airplanes flying overhead	94	4	1	1	--
Vegetation damage	69	14	14	3	--
Cut tree limbs	68	18	10	3	1

Preferred Sources of Information About Fossil Creek (n=114)

Information Source	Percent*
On-site information kiosks or bulletin boards	59
Interacting with Forest Service staff on-site	24
Contacting Forest Service offices	16
On the Forest Service website	54
Be on a Fossil Creek mailing list	30
Brochures, other information available on-site that I can take with me	45
Self-guided interpretive trails on-site	30
I am not interested in receiving information about Fossil Creek	11

*Totals more than 100 percent due to multiple responses.

Services Preferred at Fossil Creek (n=108-113)

Service or Facility	Not important	Somewhat important	Extremely Important	Don't know
	- - - - - - - - - - - - percent - - - - - - - - - - - -			
Restroom facilities	28	33	39	--
Drinking water	41	33	25	1
Developed campgrounds	71	22	5	2
Developed picnic areas	69	24	6	1
Group campsites	70	21	5	4
Group picnic (day use) areas	68	23	6	3
Directional signs on the roads	45	32	21	2
Directional signs on the trails	44	31	23	2
Having Forest Service personnel on-site	61	30	8	2
Garbage cans at recreation sites	12	27	59	3
Handicapped access to the creek	57	25	8	10
Fishing opportunities	52	22	19	6
Dispersed (undeveloped) campsites	14	33	51	2
Designated dispersed campsites	45	33	17	5
Historical interpretation of the Childs and Irving power plants	37	32	27	4
A system of designated trails in the Fossil Creek area	30	29	38	3

Support for Changes in Recreation Management of Fossil Creek Area (n=99-104)

Management Changes	Support	Do not support	Don't know
	- - - - - - percent - - - - - - - -		
Upper Fossil Creek – Irving upstream			
Allow day use only	23	66	11
Prohibit campfires	28	59	13
Construct a trail system between Fossil Springs and the current dam site	64	22	14
Middle Fossil Creek – Irving			
Continue to allow camping but only in designated dispersed (undeveloped) camping sites	63	24	13
Move dispersed (undeveloped) camping away from the creek	38	43	18
Limit vehicle access near the creek	58	31	11
Construct a non-motorized trail along Fossil Creek between Irving and the junction of Forest Roads 708 and 502	65	20	15
Provide interpretive information on-site on the natural and cultural features of Fossil Creek	79	9	12

Visitor Demographics

Home State (n=117)

State	Percent
Arizona	98
New Mexico	2

Gender (n=114)

	Percent
Male	64
Female	36

Race (n=111)

	Percent
African American	1
Asian	1
Caucasian	87
Hispanic	7
Native American	1
Other	3

Employment Status (n=117)

	Percent
Employed full-time	68
Retired	9
Full-time student	6
Employed part-time	3
Part-time student and employed	3
Full-time homemaker/care giver	2
Self-employed	2
Full-time student and employed	2
Part-time student and employed part-time	2
Other	2
Unemployed	1

Appendix D. Metric to English Conversion Table.

Approximate Conversions from Metric Measures

Symbol	*When You Know*	*Multiply by*	*To Find*	*Symbol*
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares	2.5	acres	(10,000 m^2)
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
	metric ton	1.1	short tons	(1,000 kg)

VOLUME

mL	milliliters	0.03	fluid ounces	fl oz
mL	milliliters	0.06	cubic inches	in^3
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3

TEMPERATURE (exact)

°C	degrees Celsius	multiply by 9/5, add 32	degrees Fahrenheit	°F

Endnotes

[1] The Mogollon Rim is a 1,000-foot escarpment which extends northwestward across Arizona for 200 miles and represents the eroded edge of the Colorado Plateau. This marks the northern edge of the Transition Zone, a belt of rugged mountains and large structural drainages which separates the physiographic provinces of the Colorado Plateau to the north and the Basin and Range to the south (Nelson 2003).

[2] Five outstanding remarkable features associated with Fossil Creek were identified. These include: geologic values, for the unusual travertine deposits; fish, for the headwater reach with an entirely native fish community; wildlife, for the high diversity of habitat and abundance of wildlife species; historic, for its high heritage value associated with both prehistoric and historic sites; and, riparian, for its mostly undisturbed riparian habitat (USDA 1993).

[3] Full flows were not returned to Fossil Creek until June 18, 2005.

[4] On October 8, 2004 FERC issued an Order Approving Surrender of License and Removal of Project Works for the Childs Irving Project. In that order, FERC stated that they will require the removal of the top 14 feet of the Fossil Springs Diversion Dam. They elaborate, stating "APS and the Forest Service propose that they jointly make a final decision on addional removal of the Fossil Springs dam during the project removal process. We will not leave the extent of dam removal unresolved in approving this surrender; therefore, this order will require only the removal of the tope 14 feet of the dam" (October 8, 2004 Order, page 15).

[5] This section excerpted from *Fossil Creek Planning Area Existing Condition, Soils, and Water Quality Report*, Rory Steinke, Coconino National Forest, September 17, 2002. Note that this section summarized information for a watershed boundary that includes a larger portion of the Verde Watershed than the watershed boundary used in this report (see Figure 5).

[6] The information in this report is summarized from the Forest Service draft specialist report for the Fossil Creek Planning Area (2003).

[7] This section is excerpted from *Fossil Creek Watershed Analysis, Affected Environment, Fisheries, Version 1.1*, Coconino National Forest, December 6, 2002, Mark Whitney, Forest Fisheries Biologist. Minor edits and clarifications were made based upon reviewer's comments.

[8] Cypriniform: group of fish within the taxonomic order Cypriniformes that contains the taxonomic families Cyprinidae (minnow, chub, etc.) and Catostomidae (suckers).

[9] Piscivorous: fish-eating.

[10] This section excerpted from *Fossil Creek Watershed Analysis, Affected Environment, Fisheries*, Coconino National Forest, Mark Whitney, Forest Fishery Biologist, December 6, 2002.

[11] Taxon: a general term for a taxonomic group (Family, Genus) whatever its rank.

[12] The Verde River lies within the Gila River Basin of the lower Colorado River Basin.

[13] Melanophore: pigment cell containing melanin (black) (Minkley 1973).

[14] Gonopodium: modified anal fin of males of live-bearing fishes, comprising fin-rays 3, 4, and 5. Used in transfer of spermatophores to genital pore of femal (Minkley 1973).

[15] Antimycin A is an organic compound that was isolated from the bacterium *Streptomyces girseus* in 1945. It was later found to be toxic to fish and was patented as a piscicide in 1964. The formulation used in the Fossil Creek native fish restoration project is Finitol-Concentrate (liquid form of Antimycin A) and Fintrol 15 (antimycin A coated sand) (USDI/USDA 2003). Antimycin acts at a cellular level to interrupt repiration of fishes. It degrades quickly in warm water and with exposure to turbulence and to sunlight. Potassium permanganate is used to neutralize antimycin (USDI/USDA 2003).

[16] Management Indicator Species (MIS) are defined in 36 CFR 219.19 which states that "In order to estimate the effects of each alternative on fish and wildlife populations, certain vertebrate and/or invertebrate species present in the area shall be identified and selected as management indicator species…These species shall be selected because their population changes are believed to indicate the effects of management activities." In addition, the CFR states that "in the selection of management indicator species, the following categories shall be represented when appropriate: Endangered and threatened plant and animal species identified on State and Federal lists for the planning area; species with special habitat needs that may be influenced significantly by planning programs; species commonly hunted, fished, or trapped; non-game species of special interest; and additional plant and animal species selected because their population changes are believed to indicate the effects of management activities on other species of selected major biological communities or on water quality."

[17] The "sunfish barrier" is a term used by those involved in the fall 2004 native fish restoration project. It is a natural "barrier" to sunfish movement and is located approximately 0.5 miles below the Fossil Springs Diversion Dam.

[18] Section 106 of the National Historic Preservation Act, as amended in 1992, establishes the basis for determining effects to cultural and historic sites as eligibility for inclusion in the National Register of Historic Places. Significance, the level of importance a site has in local or national culture or history, is a central concern in the evaluation of such eligibility and is determined by applying the National Register Criteria for Evaluation as defined in 36 CFR Part 60.