USA: Arizona: Fossil Creek Watershed and Riparian Restoration

Overview

Fossil Creek is a spring-fed, travertine-forming riparian area in northern Arizona that is home to several endangered species of native fish, as well as many important species of birds, mammals and herptofauna. A diversion dam built in the early 1900s to supply water to two hydroelectric stations diverted almost the entire flow of the creek and drastically altered the ecosystem. In 1999, Arizona Public Service (APS) signed an agreement to decommission its hydroelectric facilities along Fossil Creek and allow the restoration of full flow to the streamcourse. In preparation for this measure, the Native Fish Renovation Project was implemented to eradicate nonnative species from the stream and help strengthen populations of native fish. The successful completion of this project and the ongoing deconstruction and restoration activities along the creek offer hope that this unique watercourse will soon be restored to its former splendor.

Quick Facts

Project Location:
Fossil Creek, Arizona, USA, 34.3452426, -111.66607249999998

Geographic Region:
North America

Country or Territory:
United States of America

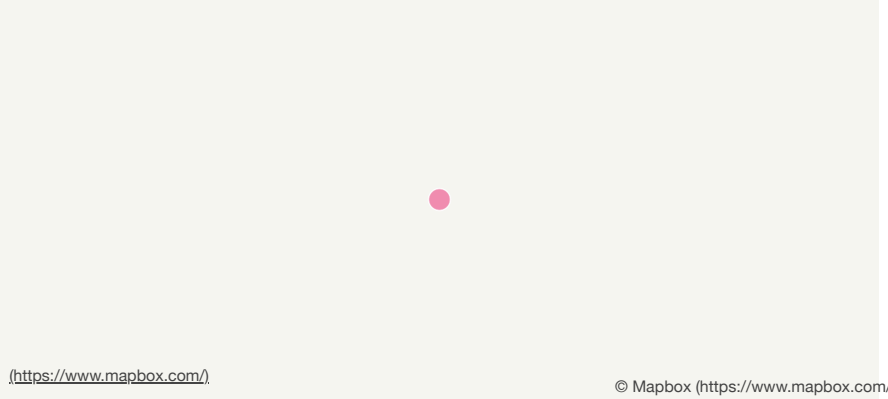
Biome:
Freshwater

Ecosystem:
Freshwater Rivers & Streams

Area being restored:
14 miles of watercourse

Organization Type:
Other

Location



TIMEFRAME

Project Stage:
Implementation

Start Date:
2004-08-22

End Date:
2010-01-22

DEFINING THE PROBLEM

Primary Causes of Degradation

Invasive Species (native or non-native pests, pathogens or plants), Urbanization, Transportation & Industry

Degradation Description

The Childs Power Plant was built in 1909 on the banks of the Verde River and was one of the first hydroelectric power plants in the West. Electricity generated there was used by the mining industry in the Jerome area, and by large irrigation companies and individual farmers in the Verde Valley to run pumps to irrigate thousands of acres of land. In response to increasing power demands by the end of 1914, precipitated by the high price of copper and the revival of the mining industry, the Irving Power Plant was built at Fossil Creek in 1916.

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 spring-supplied baseflow (nearly 46 cfs) of Fossil Creek into a system of flumes, siphons, penstocks, a reservoir (Stehr Lake), and turbines associated with the power generating facilities. 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).

Not only have hydrologic disturbances been deleterious to the Fossil Creek watershed, the introduction of nonnative fish species has also threatened the ecosystem's integrity. Since the early 1900s, at least 40 species of non-native fish have become established in the Gila River Basin in which Fossil Creek is located. Many of these non-natives were purposefully introduced to increase the diversity of the sport fishery, and some were accidentally released as bait or ornamental fish. Regardless of the mode of arrival, non-native fishes have had a detrimental affect on native aquatic species. The introduction and proliferation of non-native aquatic species, especially fish, is increasingly viewed as one of the most serious long-term threats to the

recovery of native species, equaled in severity only by the effect of habitat destruction. Nonnative species have made their way into Fossil Creek, 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. Crayfish (Orconectes virilis), another nonnative species, has also established itself in the stream.

PLANNING AND DESIGN

Reference Ecosystem Description

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 dominant community in the 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, the dominant vegetation includes velvet mesquite, catclaw acacia, prickly pear, shrub liveoak (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, and mormon tea (Ephedra viridis), birch-leaf mountain mahagony (Cercocarpus montanus) and pointleaf manzanita (Arctostaphylos pungens) are common (Baker Engineering 2002a).

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. 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. Diversity of riparian tree species is high in this area, and ash (Fraxinus velutina), alder (Alnus oblongifolia) and Arizona walnut (Juglans major) predominate (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).

Fossil Creek is one of a few streams in Arizona retaining viable populations of six native fish species, including: headwater chub (Gila nigra), roundtail chub (G. robusta), speckled dace (Rhinichthys osculus), longfin dace (Agosia chrysogaster), desert sucker (Pantosteous clarki), and Sonora sucker (Catostomus insignis). These 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.

Besides important fish species, the Fossil Creek watershed supports over 175 known species of mammals, birds, reptiles, amphibians, and terrestrial invertebrates. Four birds federally listed as threatened or endangered 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. Other common bird species are: black hawk (Buteogallus anthracinus), Bell's vireo (Vireo bellii), warbling vireo (Vireo gilvus), yellow-breasted chat (Icteria virens), Lucy's warbler (Vermivora luciae), summer tanager (Pirangra rubra), hooded oriole (Icterus cucullatus), hairy woodpecker (Picoides pubescens), and western wood pewee (Contopus sordidulus). Many of the birds in the Fossil Creek area are neotropical migrants from Mexico, Central and South America and the Caribbean that spend only a portion of each year in the area.

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.

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 also 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.

Project Goals

– To facilitate ecosystem recovery by restoring full flow to Fossil Creek
– To revitalize the native fishery in a region where native fish are increasingly rare

Monitoring

The project does not have a monitoring plan.

PROJECT ACTIVITIES

Description of Project Activities:

In preparation for the restoration of full flows to Fossil Creek, a fish renovation project commenced in the late fall of 2004. 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. This barrier is designed to keep nonnative fish in the Verde River--e.g. smallmouth bass (Micropterus dolemieu) and flathead catfish (Pylodictis olivaris)--from traveling upstream and negatively impacting the native fish. 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. Fish were captured using backpack electrofishers, baited hoop nets, trammel nets, seines and minnow traps during October 11-15. Fish intended for salvage were held in live cars placed along the stream course and were transported to the holding facility on October 15 by helicopter long line in 55 gallon drums. Transportation of captured fishes from the stream to the holding facility and back following renovation was accomplished in a variety of ways. For remote areas inaccessible by vehicle, a helicopter was employed to carry a 208 L drum on a long line. The drum contained a battery-powered aerator for providing supplemental air while fish were in transit. Fish carried inside the drum were segregated by size into two separate mesh bags. Upon setting of the drum on the ground the bags were removed from the drums and placed in a tank mounted in the bed of a pickup and driven several hundred yards to the holding raceways. In accessible areas, biologists carried fish to hatchery trucks in 19 L buckets and drove them to the holding facility. The holding facility consisted of twelve circular raceways, independently plumbed and provided with available auxiliary oxygen supply, if needed. A continuous flow of water was provided via a 2-inch high pressure (~240 psi) line fed directly from the penstock of the Irving hydroelectric turbine. Water pressure was lowered via a pressure reduction valve to about 80 psi and plumbed through 1.5 inch PVC pipes to each raceway. Outflow from the raceways was directed via 2-inch lines to a dirt holding basin or to the creek. Fintrol was selected as the piscicide for several of its qualities. First, it works at a much lower concentration 10-25 parts per billion (ppb) than the alternative, rotenone, which is generally applied at 1 part per million (ppm). Second, rotenone is ineffective on eggs, whereas antimycin is toxic to eggs and all life stages of fish and the toxic action is irreversible (Berger et al. 1969). Finally, rotenone has been shown to cause avoidance reactions in fish (Dawson et al. 1998), and the complexity of habitats found within the target reach of Fossil Creek would likely provide numerous opportunities for fish to avoid rotenone. Application of Fintrol-concentrate to the stream was accomplished using 19 L buckets modified to flow at a constant rate. A 19 L bucket design modified slightly from Stefferud and Propst (1996) was used. Expected discharge rates were used to calculate amount of Fintrol needed to charge each bucket for a 4-hour exposure period. All field crews were sent into the field with pre-measured individual containers of Fintrol for charging each of their buckets based on flow measurements made the previous evening. Backpack sprayers were used during this renovation project to apply Fintrol-concentrate to margins, backwaters and other slow-moving stream habitats. Backpack sprayers were also recharged with prepackaged containers of Fintrol-concentrate. Fintrol-15, an antimycin coated sand grain designed to treat standing bodies of water or stream pools of great depth and volume, was applied directly to deep stream pools, stream margins, densely vegetated areas, and backwaters by hand. All major pools (â‰¥1 M depth) in Fossil Creek treatment reaches were measured prior to application to determine how much sand formulation was needed to establish the target concentration of antimycin. Detoxification of Fintrol was accomplished by applying a 2.5% solution of potassium permanganate in Reaches 1-2 and 20% solution of liquid sodium permanganate in reach 4. Application occurred at 3 ppm to allow for 1ppm natural environmental oxidation, 1ppm for neutralization of the Fintrol and 1ppm for residual travel downstream from the end of the targeted reach. Application of the permanganate was accomplished using a 113L closed head drum for dispensing. The drum had been modified similar to treatment buckets but with larger size brass fittings to allow for increased dispensing rate. Green sunfish were collected from the target reach during salvage efforts the prior week and held in live cars until the treatment began. These fish were then transported to live cars placed 200 meters below the neutralization station to monitor and confirm effective neutralization of the toxicant. In addition to operation of the neutralization station, a return of about 6 cfs of water by the Irving power plant to Fossil Creek 100 meters below the waterfall further served to dilute the instream concentration of antimycin. Survival of sentinel fish below the target reach confirmed that toxicant effects did not extend beyond the area intended. Following application of the piscicide, a follow-up survey was conducted to ensure that all nonnative fish had been eliminated from the watercourse. Electrofishing using a backpack electroshocking unit was used primarily in shallow (> 1 meter deep) riffle areas in an upstream direction. Sampled habitats were randomly chosen and a minimum of 90 seconds or 150 meters were shocked in each distinct habitat type. We deployed baited miniature hoopnets (50 X 100 cm, 10 cm throat, 6 mm nylon mesh), within each priority area for separate ~24 hour hauls. Each net was baited near it's cod end by attaching a nylon mesh bag (30 x 30 cm, 6 mm mesh) containing AquaMaxTM Grower 600 for Carnivorous Species (Purina Mills Inc., Brentwood, MO). All captured fish were identified to species and measured in mm for total length (TL). Snorkeling surveys were conducted using two individuals side by side in the water doing independent identification and counts. Counts were repeated three times, compared for consistency and averaged for a single value. Only 1 green sunfish (Lepomis cyanellus) was found during this survey, so treatment was deemed effective and was not repeated. Once nonnative species had been eradicated, the native fish from the holding facility were reintroduced. The Bureau of Reclamation helicopter was fitted with a 100-foot-long cable. The native fish were placed in a 55-gallon drum, and the drum was attached to the cable. The drum was then airlifted upstream and gingerly lowered to the boulder-strewn creek side, where waiting biologists placed the fish in buckets and hand-delivered them back to their Fossil Creek home. On June 18, 2005, the Childs and Irving power plants were decommissioned, and full flow was restored to Fossil Creek. Deconstruction and removal of power plant facilities--i.e. tunnels, flumes, buildings, Stehr Lake, etc.--has started and will continue through June 30, 2010, at which time APS will turn over the land and remaining facilities to the US Forest Service for management. Concern arose about the sediments behind the dam and whether the restored river would flush the sediments out without harming downriver plants and

animals. Because any attempt to manually remove the sediment would be very costly, the Federal Energy Regulatory Commission decided to require a 14-foot lowering of the diversion dam (slated to occur in 2007) in order to allow the sediment to naturally disperse downstream during flood events.

PROJECT OUTCOMES

Ecological Outcomes Achieved

Eliminate existing threats to the ecosystem:
In September 2005, almost one year after the completion of the fish renovation project, several stream reaches within the treatment area were sampled to assess the impact of the intervention. No non-native fishes were detected, and five native fishes--headwater chub, roundtail chub, speckled dace, Sonora sucker, and desert sucker--were present. These species occurred primarily as young-of-year accompanied by a few, larger adults, indicating successful reproduction and recruitment since the project's conclusion in autumn 2004. Only one fish species, Sonora sucker, was present in the lowermost reach, and its abundance was low compared with upstream reaches. Because all post-project repatriation sites were upstream of Irving, Sonora sucker apparently was the only species that had dispersed downstream by the time of the monitoring survey. The deconstruction of hydropower facilities has been ongoing, and APS crews have now removed more than 5000 feet of steel flume on wood trestle and more than 5400 feet of concrete / steel box flume. They have drained Stehr Lake and have successfully removed all infrastructures at the Childs Power Plant site. The diversion dam will be lowered as planned in 2007.

Factors limiting recovery of the ecosystem:
Longfin dace were absent from the monitoring survey conducted in September 2005. This species was known to occupy Fossil Creek historically, and also at the time of project implementation, and if it is not found during the next monitoring period, it could be necessary to reintroduce it from an appropriate, geographically nearby population. Such a reintroduction could be simultaneous with the introduction of other species, including the threatened loach minnow Tiaroga cobitis and spikedace Meda fulgida, which were deemed suitable for the stream in the Environmental Assessment developed for the project (FERC 2004).

Socio-Economic & Community Outcomes Achieved

KEY LESSONS LEARNED

Key Lessons Learned

Restoring full flow to the Fossil Creek watercourse is intended to facilitate natural regeneration of the ecosystem. Because this will be a gradual process, the full effect of this restoration will not be known for several years.

LONG-TERM MANAGEMENT

Long-Term Management

Representative Rick Renzi and Senator John McCain introduced a bill on July 28, 2006 to designate Fossil Creek in the National Wild & Scenic Rivers System. This designation would recognize the watershed's "remarkable geology, ecology, fish, wildlife, cultural and scenic values,"□ and would protect the free-flowing condition of Fossil Creek, ensuring that it is never dammed again.

FUNDING

Sources and Amounts of Funding

Funding for the Fossil Creek Native Fish Restoration Project was provided partially through the Federal Aid in Sport Fish Restoration Act, a program administered by U.S. Fish and Wildlife Service, Division of Federal Aid. Arizona Game and Fish Department costs related specifically to holding facility design and construction and stream renovation were also supported through the U.S. Bureau of Reclamation and U.S. Fish and Wildlife Service Fund Transfer Program of the CAP Biological Opinion RPA 3-4 administered through the U.S. Fish and Wildlife Service. Renovation and follow-up monitoring of stock tanks was funded through the U.S. Bureau of Reclamation, CAP Funds Transfer Program, Task 4-47 awarded to the U.S. Fish and Wildlife Service, Flagstaff Fisheries Resource Office and Arizona Ecological Services Flagstaff Sub-Office.

Full flow was restored to Fossil Creek at a cost of approximately $13 million. APS, the utility company that formerly operated the hydroelectric facilities, has absorbed the cost of the decommissioning.

LEARN MORE

Other Resources

Northern Arizona University — Project Homepage
http://www.watershed.nau.edu/fossilcreekproject/index.htm

APS Decommissioning Project Homepage
http://www.aps.com/aps/CI/Default.html

A River Reborn: The Restoration of Fossil Creek
http://www.mpcer.nau.edu/riverreborn/description.html

CONTACTS

Primary Contact

Organizational Contact

(http://ser.org)

(https://www.facebook.com/Society

ref=