PROJECT REPORT

Beavers Are Partners in Riparian Restoration on the Zuni Indian Reservation

by Steven Albert and Timothy Trimble

Results include rapid improvements in hydrology, riparian vegetation, and wildlife habitat, including habitat for rare birds.

In the semi-arid high desert of the Colorado Plateau, the Zuni Indians of New Mexico have long known the value of healthy riparian areas, lakes, wetlands, and springs. Aboriginal Zuni land once occupied more than 20 million acres in northern Arizona and New Mexico (Ferguson and Hart, 1985), and tribal members still travel widely over this area to collect plants and animals, many of which are found only at certain wetlands or springs. On the present-day Zuni Reservation (which covers nearly 600,000 acres in east-central Arizona and west-central New Mexico) all of the springs and seeps are known and named, many of them are held sacred, and some of the most important plants and animals in Zuni culture and religion are riparian obligate species.

From a biological viewpoint these areas offer some of the best biodiversity in the region because a far greater proportion of wildlife uses the riparian corridor than the surrounding landscape. In one study we conducted in the Upper Rio Nutria Watershed, a sub-watershed of the Zuni River, 37 percent of the individual birds occupied the riparian corridor of the Rio Nutria, an area which encompasses only about 2 percent of the land area surveyed. The diversity of bird species in the riparian corridor was also far greater than in the surrounding uplands.

The Zuni Fish and Wildlife Department has begun a comprehensive program of wetland and riparian restoration. We are removing non-native plants, fencing wetlands while providing alternative water sources for cattle, and replanting native vegetation along streams and wetlands. An important and innovative component of this program is the use of beavers to restore riparian habitat.

Beavers on Zuni Land

Beaver (*Castor canadensis*) were at one time found on most streams in the Southwest in areas where there was permanent water and sufficient woody vegetation to provide food (Hill, 1982). Early explorers described lush riparian systems and abundant water in the streams. S.W. Woodhouse, a naturalist on the 1851 Lorenzo Sitgreaves expedition across the Southwest, wrote:

> "On leaving [Zuni] and following down the Rio Zuni I observed in but one place a few poplars, and near these trees was a beaver-dam... Near our first camp on the Little Colorado there were the lodges of the beaver to be seen... On the banks of this stream were growing a species of swamp-willow. The grass here was of a good quality." (Woodhouse, 1853)

An accompanying sketch shows a half-mile-wide river filled with lush riparian vegetation. As in other places in North America, however, beaver populations were severely reduced from the late 18th through the early 20th centuries. The pre-Columbian beaver population in North America has been estimated at between 60 million (Seton, 1900) and 400 million (Nowak, 1964), while current populations are only about 10 percent of the lowest estimates (estimated at 6-12 million) (Naiman and others, 1988). Where

beavers were present, they modified their habitat as no other single species did. Their dams created large areas of still water and habitat for fish, waterfowl and other birds, mammals, amphibians and invertebrates. The ponds themselves filtered sediment out of the streamwater and improved water quality downstream. Water percolated into the soil, recharging aquifers and creating moist upland habitat in the areas surrounding the dams. Over time, as ponds filled with sediment and became shallower, they eventually turned to marshes and eventually meadows. By then the beavers had moved on to other parts of the stream or watershed to begin the process anew. These dynamic shifts in habitat were important components in maintaining the biodiversity of the landscape.

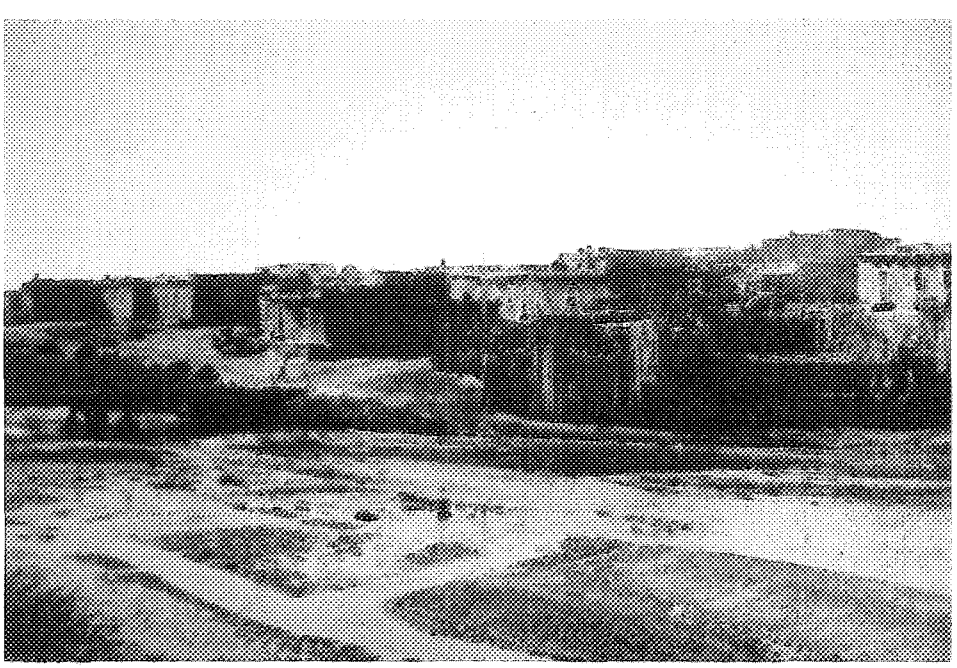
Changes to Riparian Habitat in the Southwest

With the reduction of beavers an important component in the riparian ecosystem was lost and riparian ecosystems began to degrade. Small ponds no longer filtered out sediment, and water quality declined. Vast acreages of wetlands surrounding ponds were encroached upon by surrounding, drier upland forests. Water tables were lowered, and the water budget of many watersheds decreased as water traveled rapidly downstream and out of the upper watersheds. In addition to the loss of beavers, riparian ecosystems in the region were concurrently undergoing a series of other changes, the results, either directly or indirectly, of human activities:

(1) Man-made dams have changed the hydraulics of rivers and streams, making many formerly perennial watercourses semi-perennial or ephemeral. Water stored in large lakes and reservoirs, while locally raising the water table and making water available at a few sites, reduces the availability of water in other reaches of a stream by increasing evaporation from surface water, which in this part of the United States reaches 54 inches (137 cm.) per year (Kohler and others, 1959). It also ultimately reduces the total amount of water in the system. The approximate surface area of the nine major and several minor reservoirs on the Zuni Reservation is 1,546 acres, which translates to more than 6,900 acre feet (2.25×10^8 gallons, or 8.51 x 108 liters) per year of water (Orr, 1987). In addition, many reservoirs in this area create a "sediment deficit" in their downstream watercourses. Where formerly sediment-rich river water would travel a stream, depositing and picking up sediment as it went (depending on factors such as stream velocity and channel shape), the below-dam reach of stream carries little sediment and, having nothing to deposit, can only pick up sediment—a process that can severely erode the reaches of a stream immediately downstream of the reservoir.

(2) Channelization. In an effort to reduce flooding and increase the efficiency of water transport, many rivers have been channelized, cleared of vegetation, and their sinuous shapes straightened. Unfortunately, this steepens the gradient, increasing water speed, reducing infiltration and increasing erosion. While this may reduce water lost by evapo-transpiration, it also increases direct evaporation from the water surface as shading is reduced. In addition, flash flooding increases as wetlands are destroyed or degraded.

(3) The encroachment of alien plants, including salt cedar (*Tamarix pentandra*). This plant was introduced into this country as an ornamental plant in the early 1800s and again in the early 1900s as a means of erosion control (Duncan, 1994). However, it soon escaped cultivation and spread rapidly. Salt cedar produces large amounts of seed, which germinate readily. In many situations it out-competes species such as cottonwood and willow for water and light, and uses much more water than these plants (Carmen and Brotherson, 1982). It also changes the soil chemistry of a site by bringing salts to the surface, making it difficult for other plants to survive (Hollingsworth, 1973), and in many areas it forms a dense monoculture. The tree has relatively little value for wildlife and is extremely difficult to eradicate, responding to either burning or cutting by resprouting. Removal of this plant often restores much of the natural hydrological



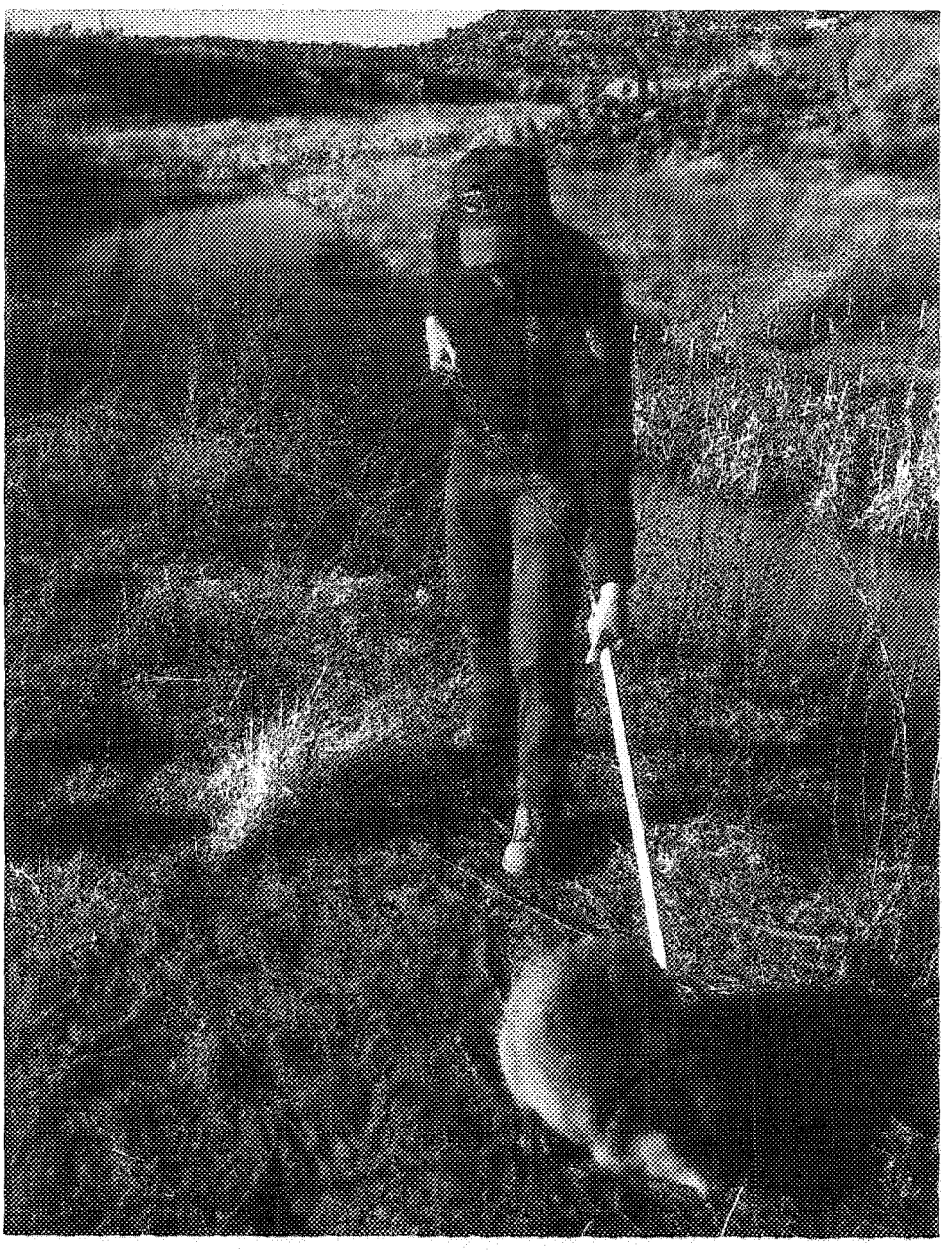
Historic photo of the Zuni River at the Pueblo of Zuni, New Mexico, taken about 1890, shows a reach of the Zuni River prior to damming. The wide, braided channel was characteristic, and was the result of a variety of factors. These included beavers, which by constructing a series of dams along the river, contributed to higher water tables, lowered evaporation rates, and available surface water year-round. *Photographer unknown. Photo courtesy of the A:Shiwi/A:wan Museum and Heritage Center*

and biological dynamics to an area (Anderson and Barrows, 1998).

Given the dramatic changes that have taken place in Southwestern riparian systems, it's no surprise that a great number of threatened, endangered, or rare species in the Southwest are found along and are partially or entirely dependent upon riparian zones.

Original Beaver Reintroduction

Knowing the effects that beavers have on their environment, we believed that selective translocation of these animals into degraded watersheds would have beneficial effects on water quality, watershed health, and riparian wildlife habitat. Selective relocation was necessary, since not every site had the potential to sustain the animals during the crucial initial stages of the reintroduction. Beginning with a small remnant population, we began moving beavers to stream areas where there was already abundant food (mostly willows), but where the stream channel was incised and didn't carry water year round, though some water, with a few relatively deep pools was necessary in order to give the beavers a safe habitat. Within a very short time, the beavers began to make a difference. Their dams, often completed within 1-2 weeks of reintroduction, slowed the flow of the water, allowing sediment to drop out of suspension and raise the stream bed. This spread water over a wider area, and larger and larger pools of water began to remain year-round. This treatment has allowed much more abundant riparian vegetation to develop, and wildlife from songbirds to deer, elk, fish, and amphibians, have begun to use these improved riparian areas.



Range Rider Timothy Trimble uses a metal pole to handle a beaver snared along the Rio Pescado on the Zuni Reservation. The authors have worked with various kinds of traps, but find that simple snares made of aircraft wire and placed along beaver trails are most effective and least traumatic to beavers. *Photos by Steven Albert*

We select beavers from a site where they are reproducing well and where their local population is stable. We take some beavers from areas where farmers or other land users report excessive damage (see discussion below) or other problems such as blocked irrigation lines or access to fields. We move the beavers during the early spring, before litters are born, or late in the summer, when the kits are grown and are relatively independent. We rarely move beavers in winter, as the animals then would not have sufficient time to build either a lodge or bank den (both types of shelters are used here) or to develop a food pile big enough to last through the season.

We use wire snares made from 3/32 in. aircraft cable which is closed into a loop through a one-way lock mechanism which tightens on the animals as they pull against it. When properly placed, these snare loops are approximately 10 inches in diameter, with the bottom suspended 2 inches off the ground. The loose end of the snare is secured with additional wire to any sturdy object such as tree or rock, or in some cases a clump of firm vegetation. The loop should be large enough for the beaver to get its head and one limb through the opening (beavers have a wedge-shaped

Here beavers introduced just five years earlier, have turned a narrow channel with ephemeral water flows into a year-round wetland that now supports willow flycatchers, snipe, an occasional yellow-billed cuckoo, and dozens of other birds. *Photos by Steven Albert*

skull, which is very difficult to snare). In the past we have used both cage traps and leg-hold traps, but have found that snares are more effective and far less expensive. We place the snares along well-used trails or at sites where beavers come on land to feed. The snare site is occasionally baited with beaver scent or freshly cut willows. The wire from the snares blends well with the surrounding twigs, and beavers will usually move part way through the loop of the snare before realizing they are caught. If they continue to move forward they pull the snare tighter and are firmly held.

These runway and feeding sites usually have a tree large enough to secure the snare, and this method also traps the beaver on dry land where the possibility of drowning is minimized. We occasionally place snares along spillways on beaver dams and/or paths through aquatic vegetation, but these areas have the disadvantages of deep water (which could drown a beaver or make it difficult to disentangle) and of providing few places to fasten snares.

With proper use and snare placement, mortality rates are approximately 5 percent or less. Mortalities generally occur when a beaver gets entangled in water deep enough to drown the animal or other beavers attack it while it is in the snare. We have had two beavers that were shot while trapped in our snares. Checking the traps every day minimizes both mortality and trauma from all of these causes.

Once we find a beaver caught in a snare, we hold it down firmly with a catch pole and lead it into either cage or a large plastic or metal garbage can, where the snare is cut off (snares generally cannot be re-used). This often requires two people but it can be done by one experienced handler. A garbage can is easier than a cage for one person to handle and has the advantage of protecting workers from bites. The cage works well when the animal needs to be transported a long distance or through rough country, where two people can carry it suspended from a pole or shovel handle. Most beavers behave aggressively when first approached in the snare, but calm considerably when confined. We have never had to chemically immobilize beavers, though this can be done, and we have never been bitten. We try to release the animals the same day they are caught, but have held them as long as 48 hours without apparent ill effects to the animals. We recommend keeping the animals in a cool, dark, quiet place, which keeps them calm and minimizes stress and possible complications (Day and others, 1980).

Male and female beavers (especially sub-adults) are difficult to differentiate with the limited handling we do since they are approximately the same size (Nowak, 1964) and do not have easily visible sexual organs. From our observations, sexes do seem to differ in the amount of bites and wear on the head and tail (males will have more—the result of fights). Adult females have prominent mammaries during the breeding season.

We have been particularly successful when turning three or more beavers loose in the same area. Sub-adults seem more inclined to stay in a relocation area than adults with an already established territory. We try to move beavers relatively far from their home territory or watercourse to minimize the likelihood that they will return to the site from which they were trapped.

Characteristics that we look for in a release site are: (1) at least some available water lasting into the early summer; (2) enough cattails and/or willows or other woody vegetation for the beavers to eat (though we have read of food being brought in for beavers until natural vegetation gets established around ponds); and (3) an area that has the potential to provide the greatest benefit to wildlife—in other words, it is close to other suitable habitat or it was formerly high quality habitat.

Results and Benefits

We have relocated about 23 beavers into seven riparian rehabilitation areas on the Reservation (Table 1). We have moved from one to five beavers at a time, with an average number of approximately three.

In most cases, within a very short time, the beavers begin building dams and holding back water. Within one year, the beavers generally will have created a well-established series of dams, which begins to salvage enough water to improve habitat. Within three to five years, remarkable changes will be evident, including very large increases in available surface and subsurface water, riparian vegetation, and reduced erosion. The most marked changes are:

Table 1. **Summary of Beaver Relocations on the Zuni Reservation.**

Location	Date(s)	# Moved	Results
Pescado	circa 1985	unknown	Large resident population established, large number of dams and riparian habitat. Some animals cause problems by clogging irrigation canals and culverts with debris.
Blackrock	unknown	unknown	Large resident population established and extensive riparian habitat has developed. Three new willow flycatcher territories. Have turned several pastures into a 100 acre-wetland complex.
Upper Nutria	1992-3	4	Considerable increase in year-round water. Extensive riparian habitat, especially willows developed. Two new willow flycatcher territories.
Nutria/Pescado Jct.	1993	3	Beavers left immediately. No food available.
Lower Gallestina	1997	4	Some dams and habitat development evident.
Plumasano	1997	3	Immediately left area. One beaver burrowed into a dirt irrigation dam, causing damage.
Sandy Springs	1998	1	Died or left area.
Sandy Springs	1999	4	Well-developed series of dams. Not much increase in vegetation yet.

Improved Hydrology: Once plants get established, the cycle of reduced erosion and increased plant health becomes self-perpetuating. The plants trap more sediment, reduce erosion, and slow the flow of water, allowing it to percolate into the soil and raise the water table, which in turn increases the abundance and productivity of the plants.

Reduction of Salt Cedar Infestation: In some parts of the Reservation, we have undertaken an extensive salt-cedar eradication effort. While beaver unfortunately do not eat salt cedar, the raised water tables and ponds of surface water they create have killed salt cedar in some areas. Native willows and cottonwoods are much more tolerant of inundation. Other researchers (Everitt, 1980) have reported that salt cedar apparently does not do well under conditions of frequent or severe flooding, while native species such as cottonwood and willow thrive under these conditions.

Willow Flycatchers: One of the species that has benefited most from the beaver relocations is the southwestern willow flycatcher (*Empidonax traillii extimus*), federally listed as endangered in 1998. This small neotropical migrant is a riparian-obligate passerine, one of four recognized subspecies of the willow flycatcher. It nests in riparian areas and near wetlands and lakes where there is dense growth of willow and other riparian species, often with a scattered overstory such as cottonwood. Like many flycatchers, it is insectivorous, and it uses high perches from which it forages and advertises its territory. This species seems to require open water as a feeding area (Tibbitts and others, 1994).

Before the beaver relocation program, the Reservation normally had from three to five flycatcher territories in use in a given year. In the last three years, singing males or pairs of flycatchers have established territories in at least five additional locations, all of them with active beaver dams. In one area the loss of a lake that was drained in order to repair the dam was offset by the presence of beaver dams and ponds adjacent to the flycatcher territories. The flycatchers have continued to breed successfully despite the loss of the lake water and, since the beavers became active, the yellow-billed cuckoo, a candidate for endangered species status, has been recorded in one of the areas for the first time.

Education: Beavers provide an excellent and portable educational tool. Some of our beavers have visited classrooms from kindergarten through high school. They provide an avenue for teaching about wetlands, watchable wildlife, watershed health, and our department's activities in general. We have realized through this effort how much people's (especially children's) perceptions about the natural world depend on their immediate experience: kids become more transfixed and enchanted by this native rodent in their classroom or behind their houses than they do watching Siberian tigers or panda bears behind metal bars on a trip to the Albuquerque Zoo. We have also taken many classes out to the field to see, walk on and explore beaver dams and lodges. This is an especially useful exercise, since the kids can readily see the difference that the animals make in their environment.

Problems

Not everyone has been a supporter of the beaver program from the start. Many farmers initially complained that the beaver dams were a nuisance and kept water from entering their fields. In 1996 we got help from an unexpected source: a drought. During that summer, one of the driest in recent decades, many reaches of the Zuni River dried up, and some farmers had partial or total crop failure. One family, however, had great success by irrigating their fields directly from a series of beaver ponds with the aid of a portable pump. This helped convince many families that beavers could in fact provide benefits to farmers.

In other areas, where the river channel is relatively shallow and the arable land extends to near the river, the rising water behind the beaver dams has encroached on farm fields and pastures. While most farmers are glad to have the extra water, some are concerned about the loss of fields (some of which have been handed down for many generations) when these areas are flooded. At one farm near one of our relocation sites, two pastures that were separated by a small dirt road and a culvert through which the Zuni River passed have become a 50-acre wetland with year-round water, fish, waterfowl, willow flycatchers, yellow-billed cuckoo, and snipe (a rare breeder in New Mexico) during the breeding season.

We are reluctant to remove the beavers from the habitat they have created, and we are currently working with this farmer to find an adequate road crossing and access to his far pastures.

Another problem that we've encountered is the fact that the beavers will cut down most of the large trees in an area where they become especially abundant. Some areas look as though they've been hit by a cyclone, with cottonwood trees strewn everywhere, both in and out of the channel. In former times, beavers may have migrated to other areas once their habitat was so altered, allowing it to recover; however, with the limited habitat that we have available in Zuni, we prefer to protect the trees that we can. To do this we cover the trunks of some trees with sheets of aluminum. We get used 16" x 32" aluminum printing plates from a local newspaper. We de-ink them as best as we can with lacquer thinner and nail one to four sheets on the trunk from ground level up to 32 inches. We have also seen chicken wire and steel screen used to protect trees from beavers. While perhaps visually unappealing, these methods are quite effective at preventing beavers from cutting these protected trees.

One reintroduction site appeared to have ideal habitat in an incised arroyo with a relative abundance of water. However, the site was adjacent to an earthen dam that impounds a 50-acre lake. The one beaver we introduced soon made its way into the lake and began excavating a bank den in the earthen dam, damaging the dam and the road atop it.

One persistent problem that we've encountered is how to treat smaller arroyos that have little vegetation. In an evaluation of the causes of siltation of a critical wetland in the Upper Nutria Watershed, we found that a single arroyo contributed 96 percent of the sediment that was deposited, despite the fact that the area drained by the arroyo was only 16 percent of the watershed area. Transplanting beavers into these areas has proved to be problematic when there is not enough vegetation to serve as a reliable food source for the animals. In these cases, some initial planting of willows prior to reintroduction may be needed. However, we have had success transplanting beavers into arroyos that have barely enough water to keep a few small ponds filled year-round, so permanent water is not strictly a necessity.

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