Arizona Riparian Council

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PART 1: RESTORATION OF RIPARIAN VEGETATION IN THE ARID SOUTHWEST: CHALLENGES AND OPPORTUNITIES

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Editors' Note: This year is the end of a millennium and next year will begin the next. Many, many features of the land have changed over that time, both naturally and through the influence of humans. Recently, the buzzword has become "restoration." Beginning with this issue we are printing Part 1 of a paper by Julie Stromberg that was presented at the "Restoring and maintaining riparian vegetation in the US Southwest" a U.S. Fish and Wildlife Service/Bureau of Reclamation workshop on Restoring Natural Function to the Lower Colorado River held in Las Vegas, Nevada, on July 8-9, 1998. Parts 2 and 3 will be in the next two newsletters.

INTRODUCTION

Before we attempt to restore an ecosystem, we need to understand the factors that have caused the degradation (Briggs 1996). This step of identification of root causes hinges upon an understanding of the ecological impacts of a lengthy list of human activities relating to water and land use, and species introductions and extirpations. We also need to have some feel for the ecological endpoints that the ecosystem is capable of achieving. This depends upon an understanding of the physical and biological processes that influence the ecosystem, an assessment of the present site conditions, and knowledge of the life histories and tolerance ranges of dominant species. To develop and implement restoration strategies, one should tap into the expertise of fluvial geomorphologists, hydrologists, biologists, and in some cases, engineers. Successful implementation ultimately depends on coordination with, and support from, a wide array of land owners, managers, and otherwise effected or interested parties.

Clearly, knowledge is important for restoring ecosystems. Intuition also is helpful, and money can't hurt! In this paper, I address the first part of this triumvirate. I review some of the strategies for restoring riparian ecosystems in the arid Southwest, after setting the stage by musing about what it is we are trying to restore.

What Conditions Do We Want to Restore? One of the goals of ecological restoration is to restore the structure and function of a site to that of its historical, natural condition or of indigenous reference sites. In other words, the goal is to restore ecosystem integrity. Woodley (1993) states that: "Ecological integrity is defined as a state of ecosystem

(*Cont. pg. 3...Restoration)*

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PRESIDENT'S MESSAGE

This past November, Arizona Public Service (APS) announced that it will close its two hydroelectric plants on Fossil Creek and restore full flows to 14 miles of stream. This represents a significant stream restoration achievement in the Southwest. The Arizona Riparian Council can take pride in its efforts to restore the stream which date back to our Fall Camp Out at the Irving Power Plant in 1992.

The Council's main role in this effort has been to highlight how truly outstanding the natural resources of Fossil Creek are and the singular opportunity for restoration this riparian ecosystem offers; we have long advocated returning fulls flows to the stream. Because of the uniqueness of Fossil Creek's restoration potential, it was a relative easy task to help convince all the parties involved of the merits of restoring the stream. There was little discussion on whether or not to restore the stream; instead, the question was "how do we restore it?"

A coalition of environmental groups was formed to advocate for restoring the stream and to negotiate with APS. This coalition was headed by American Rivers who was a driving force in restoring flows and whose expertise in dam decommissioning was invaluable. APS also deserves recognition for its cooperation and willingness to work with the environmental coalition. They chose to be good corporate citizens and do what was environmentally responsible.

The agreement to restore Fossil Creek was reached through collaboration, not ligation. This is important because the next step in the process, figuring the nuts and bolts of restoring full flows, will be helped by a good working relationship and trust between APS, agencies, and the environmental coalition. The Council intends to continue its involvement in the settlement process.

Marty Jakle has been the person "leading the charge" for the Council. I want to thank him for all the time and effort he has spent working on this issue. Marty, your perseverance that this could really happen is one of the main reasons this seemingly impossible dream is now coming to fruition. Your diplomacy and enthusiasm are greatly appreciated. Thank you.

Kris Randall, President

Fossil Creek. Photo by Mitchell Laidlaw October 1999.

(Restoration...Cont. from pg. 1)

development that is optimized for its geographic location, including energy input, available water, nutrients and colonization history.....It implies that ecosystem structures and functions are unimpaired by human-caused stresses and that native species are present at viable population levels."

Given my background, I take a plant-centered approach to restoration of site quality or biotic integrity. I want structure and function to be restored to the plant communities, fully recognizing that healthy plant communities depend on physical integrity. To me, restoring structure means restoring a wide array of plant species and functional groups, restoring viable age structures for the dominant species, restoring vertical complexity, and restoring a mosaic of vegetation patches in the floodplain. Restoring function means, among other things, restoring bioproductivity, and restoring the ability of the plant communities to capture and store nutrients, build soils, stabilize stream banks, and create habitat for animals. As well, the plant community should be self-sustaining and resistant or resilient to various types of natural disturbances.

At Sonoran riparian reference sites, such as the Hassayampa River Preserve or the San Pedro National Riparian Conservation Area, we find several hundred different plant species per several mile river reach and we find these plants in functional groups ranging from obligate wetland to obligate upland groups (Wolden et al. 1995; Stromberg et al. 1996). We find a mosaic of vegetation patches, including cottonwood-willow (*Populus-Salix*) forests, mesquite (*Prosopis*) woodlands, open shrub lands and marshlands. We find populations of flood-dependent tree species like cottonwoods and willows in patches ranging from saplings to old trees, with the relative abundance of the former (and the flood plain turnover rate) increasing as one proceeds downstream. We find that biotic interactions are intact: for example, sufficient plants are flowering over the growing season to support a diverse population of pollinators and sufficient pollinators are present to allow for high seed set of the plants. Generally, structure and function are interrelated, and, for example, the more structurally complex an area is, the greater is its ability to create habitat for a wide variety of insects and birds.

What Are the Symptoms of Degradation? To a large degree, the question "What do we want to restore?" is the flip-side of "What are the symptoms of degradation?" Within Southwest riparian ecosystems, we find a continuum of degradation. We do have some healthy, reference areas, although it is difficult to find any that have not been altered humans in some fashion. At the other extreme we have sites that have lost their riparian biotic community and the physical platform that sustains them. A drive to the middle Gila River, where groundwater is now several hundred meters below the floodplain, provides us with such an example (Judd et al. 1971) In between, we find a range of site quality, depending on the extent and combinations of stressors to which the ecosystem has been subjected (Busch and Smith 1995). There have been some attempts to quantify the state of riparian ecosystem health and to determine the amount of federal riparian range land in degradation classes (GAO 1988; Ehrhart and Hansen 1997). Such efforts should be continued and expanded.

Mesquite

The symptoms of degradation vary depending on one's way-of-seeing and area of expertise. To a fluvial geomorphologist, prime indicators of degradation may be reduced stream meandering, presence of incised channels, or, in other settings, presence of wide, shallow stream channels. To a hydrologist, these indicators may include declining ground water levels or stream flow patterns that deviate from natural patterns. A plant ecologist may look to see whether a site has little capacity for self-repair or revegetation after flood disturbance, or if species-rich communities have been replaced by homogenous thickets of tamarisk (*Tamarix* *ramosissima*), giant reed (*Arundo donax*), Bermuda grass (*Cynodon dactylon*), or other exotic species. A wildlife biologist may test for declining diversity of bird species, or population declines of riparian specialist species such as Yellow-billed Cuckoos (*Coccyzus americanus*) or Southwestern Willow Flycatchers (*Empidonax traillii extimus*). To a range ecologist, symptoms of degradation may include soil compaction, stream channel downcutting, lack of tree regeneration, and spread of unpalatable plant species. A loss of biotic interactions – such as a loss of pollinators, a breakdown of plant-disperser interactions, or a loss of symbiotic relationships such as plant-fungi mycorrhizal relationships – are yet other types of indicators of degradation.

How Much Do We Want to Restore and Where Should We Focus Our Efforts? There are many approaches to setting riparian restoration goals and prioritizing objectives (Kershner 1997). One approach for answering the "how much and where" questions is to adopt a focal species or umbrella-indicator species approach (Lambeck 1997). This would involve selecting a group of species that are indicators of a full range of riparian site conditions. Each different focal species would define "different spatial and compositional attributes that must be present in a landscape and their appropriate management regimes" (Lambeck 1997). The selected species should encompass longitudinal variation in riparian site conditions (e.g., headwater streams to riverine deltas), lateral variation within sites (e.g., streamside marshes to floodplain forests), regional variability (e.g., Mojave Desert rivers and Sonoran Desert rivers), and temporal or successional variability (e.g., young to old-growth cottonwood-willow forests). Next comes the crucial step of managing for viable populations of (and thus restoring sufficient habitat to support) the focal species. Threatened or endangered species of riparian habitats will probably lend themselves well to inclusion in this group. For example, viable populations of Southwestern Willow Flycatchers and Yellow-billed Cuckoos would suggest, respectively, that the processes that allow for the development of early-successional willow forests and mature cottonwood stands, are intact.


Southwestern Willow Flycatcher

Why Bother? This all begs the question of, what value is this to me? Ultimately, restoration efforts are beneficial to humans. Healthy ecosystems are essential for sustaining human populations in the long-term. The services provided by riparian ecosystems encompass ground water recharge, water quality improvement, pollination of agricultural crops by insects, pest control by insectivorous birds and bats, and maintenance of species diversity as a reservoir for future food crops or medicinal purposes. These services are less tangible than, say, crop production on floodplain lands, but are of real value nonetheless. Costanza et al. (1998) have estimated that the economic value of services provided by ecosystems – as opposed to goods such as food crops – is over several trillion dollars. Still unaccounted for in this analysis are "mental health" services, with riparian ecosystems providing aesthetically pleasing sites for recreation, relaxation, reflection, and discovery.

HOW DO WE RESTORE DEGRADED ECOSYSTEMS?

1)Restoration of Physical Elements and Processes

Hydrologic regimes and fluvial geomorphic processes are prime determinants of riparian community structure. To restore a diversity of plant species, growth forms, and age classes, we need to restore the diversity of fluvial processes-such as movement of channels, deposition of alluvial sediments, erosion of aggraded flood plains – that allow a diverse assemblage of plants to co-exist. To restore bioproductivity and maintain plant species with shallow roots and high water needs, we have to ensure the presence of the necessary hydrogeomorphic elements – notably water flows, sediments and nutrients. We need to restore flows of water, sediment, and nutrients not only in sufficient quantities but with appropriate temporal patterns (Poff et al. 1997).

We have ample room to practice these restoration techniques, given the extent to which hydrogeomorphic conditions have been altered and fluvial processes disrupted. In the U. S. Southwest, there are over 400 dams that are managed for hydropower, flood control, or municipal or agricultural water supply (Graf 1999). Surface water is diverted from dammed and undammed rivers alike. Groundwater is pumped from flood plain aquifers and regional aquifers. Dikes and berms constrain channels and reduce river-floodplain connectivity. Throughout our watersheds, livestock grazing, fire suppression, and urbanization have reduced rates of water infiltration into soils and increased surface runoff. This, in turn, results in larger flood peaks, higher sedimentation rates, and reduced base flows. On the positive side – there are many restoration opportunities that we can not afford to overlook.

Flood Flows and River Dynamism. The ultimate strategy for restoring natural processes is to remove all impediments to the natural flow regime, which in many cases means removing dams. This type of approach falls within the realm of passive restoration: one removes stressors, restores natural conditions and processes, and then allows the biotic communities to recover of their own accord (Middleton 1999).

Dams are being removed in the American West for the purpose of restoring habitat, and most often for endangered fish species. Working within drainage basins, some groups have contrasted the relative costs and benefits of a suite of dams with respect to economics and ecology (Shuman 1995; Born et al. 1998). Removal of certain dams, such as those on the Elwha River in Washington State, would result in the loss of only a small amount of hydropower while providing substantial ecological benefit (Wunderlich et al. 1994). One can find analogous cases in the Southwest, such as the dam on central Arizona's Fossil Creek. There is a strong likelihood that this dam will either be removed or at least no longer operated for hydropower production (*Editors' note: See President's Message*, page 2). Similarly, there may be a case to be made for the removal of Alamo Dam on the Bill Williams River in western Arizona: the ecological benefits of dam removal may outweigh the benefits of recreating in Alamo Lake and reducing flood peaks and sediment flow into the Colorado River. These issues of dam removal and decommissioning should be explored systematically. Although there may only a few dams that qualify for removal, that should not dissuade us from pursuing this strategy.

We can make other compromises with respect to river management. Despite demands on water supply or power supply, we can find creative ways to work within the political and institutional constraints to rehabilitate, if not fully restore below-dam ecosystems (Cairns 1995). For example, we know that the timing, magnitude, frequency and duration of flows are all important influences on riparian vegetation. We can rehabilitate riparian ecosystems by naturalizing flows so as to mimic the natural hydrograph, or flow pattern, of the river. This was done on the St. Mary and Oldman Rivers, in Alberta, Canada (Rood et al. 1995; Rood et al. 1998; Rood, pers. comm.). The St. Mary River is managed for delivery of summer irrigation water. Peak flows still occur fairly frequently. Thus, rates of river meandering and channel realignment are relatively intact, and so to are the processes that create the “nursery bars” needed for germination of cottonwood seeds. However, during the

Fossil Creek Dam. Photo by Allan Zisner, October 1999.

recession limb of the flood, water managers tended to rapidly reduce the flow rate rather than allowing for a slow attenuation. The result was high cottonwood seedling mortality. So, a water agreement was reached wherein the "ramping rate" would be reduced during flood years such that the stream stage did not drop more than 4 cm per day, a rate that allows the roots of cottonwood seedlings to keep in contact with moist soil. Another part of the agreement calls for an increase in summer base flow levels, thereby reducing the risk of death from drought for very old and young trees, in particular. However, demands on water quantity by the surrounding communities continue as a looming threat.

Another compromise was made for the Truckee River in Nevada (Gourley 1997). The Truckee has been subject to many degrading factors. It is regulated by dams, channelized in areas, and diverted for agricultural and urban uses. There has been loss of age class and structural diversity within the cottonwood forests and a collapse of native fish populations. Without dense stands of young cottonwoods, the channel has widened, and water temperatures have increased – one factor that is contributing to reproductive failure of fish species including the endangered cui-ui (*Chasmistes cujus*). Thus, representatives of several agencies planned a spring flood to help restore the below-dam ecosystem. The first flood was intended to stimulate reproduction of the fish. When it was observed that the flood pulse also met the regeneration needs of the cottonwoods, another spring flood was planned for the specific purpose of allowing for cottonwood reproduction: flows were released at a specific time in spring when the cottonwood seeds are viable, and flood waters were allowed to recede slowly, per recruitment models. Seedlings were most abundant on fluvial surfaces that had been formed by past floods, such as abandoned channels where the water table was closest to the surface. However, because of constraints on maximum flow releases from the dams, it is not possible to release the large scouring floods that serve to prepare seedbeds. Thus, alternative measures – such as bulldozers – may be necessary to mimic the functions that have been lost by truncating the flow peaks. These "active" restoration approaches, wherein one intervenes with some type of engineering approach or physical action, can serve to mimic natural processes and conditions at sites where natural processes can not be fully restored (Friedman et al. 1995).

The Bill Williams River in western Arizona also illustrates the challenges and opportunities of managing regulated rivers (Shafroth et al. 1998; Shafroth 1999). Flow in this river is regulated by a young dam that was built mainly to minimize flood pulses into the Colorado River. Total annual stream flows have not changed greatly due to dam construction: evaporative losses from the reservoir are high but water is not diverted from the river. The temporal pattern of flow release has changed greatly, however. The size and frequency of winter and summer flood peaks have been sharply reduced, while base flows have increased. A net effect has been a large increase in riparian vegetation cover below the dam, much of which lies within a National Wildlife Refuge. Most of the vegetation, however, consists of tamarisk. Much of the floodplain now functions as a terrace, in that it lies above the zone actively influenced by the river flows. Fires have become more frequent because floods no longer remove dead stems and woody debris, putting nonfire adapted species such as Fremont cottonwood (*Populus fremontii*) at risk.

To encourage a more natural riparian ecosystem along the Bill Williams River, refuge managers, Army Corps of Engineer employees, and university scientists have worked together to develop a flow-release plan that calls for high base flows and periodic flood (flushing) flows. Due to constraints imposed by this dam, however, more extensive restoration will require some type of active intervention. As on the Truckee River, refuge managers at the Bill Williams have discussed using bulldozers to remove vegetation, form fire breaks, and create seed beds for riparian forests. On any regulated river, one also needs to address issues of depletion of sediment and nutrients, and increases in water salinity.

Ideally, rivers such as the Bill Williams River could be used to study the effects of different flow scenarios. Here, we could test our knowledge of how to restore the native trees to dominance, by managing for the cottonwoods and willows and against tamarisk. Some strategies to test: 1) When releasing winter/spring regeneration floods, limit the summer duration of the flood flows. Fremont cottonwood and Goodding willow (*Salix gooddingii*) will be favored if germination sites are moistened only during spring, but become dry during summer when the tamarisk continue to disperse their seeds (Stromberg 1997). 2) Release post-germination summer floods to increase the relative mortality of tamarisk seedlings (Gladwin and Roelle 1998). Seedlings of the native pioneer trees may be better able to survive summer flood scour. 3) Maintain high summer base flows and water tables, to give a competitive edge to the native species. In reaches of the Bill Williams where flows are perennial, tamarisks outnumber cottonwoods and willows by a smaller margin than in the seasonally intermittent reaches (Shafroth 1999).

These examples have focused primarily on restoring the hydrogeomorphic conditions needed for one or two of the many biotic elements in riparian ecosystems. Species such as Fremont cottonwood and Goodding willow are critical, and perhaps keystone elements, but they are only a fraction of the biotic complex. It is impossible to manage directly for every single species in an ecosystem. We can, however, focus on a subset of species that we treat as indicators of intact physical processes. We increases our odds of meeting the needs of a larger number of native species and providing sustainable ecosystem improvement if we take an ecosystem approach that accounts for natural cycles of disturbance, stream hydrology, and fluvial geomorphology (Bayley 1991; Stanford et al. 1996). We need additional restoration experiments that focus on the benefits of restoring a greater complexity of flood flows, so that regulated river restoration becomes more of a multi-species, multi-function effort.

Goodding Willow

During occasional wet years, large flows are released from many dams, regardless of ecological concerns. “El Niño” weather patterns have assisted in the restoration of rivers such as the lower Gila, by filling reservoirs to levels that required large releases into the below-dam reach. With planning, water managers could be prepared in wet years to routinely release these flows in ways that mimic the natural hydrograph and favor the native species that are adapted to the natural flow pattern. We also may be able to salvage small, functional rivers out of large, heavily regulated and diverted rivers such as the Lower Colorado and Rio Grande. Even if much of the water is diverted from the river, one can theoretically design a flood flow regime that is in scale with the new base flow level, with respect to regional flood and overall flow patterns. Although the new floodplain and riparian zone would be narrower than the historic condition, the quality of the riparian corridor could potentially be high, and could provide valuable ecological connectivity between downstream and upstream reaches. A related option for large river restoration is to construct one or more side channels (Schropp and Bakker 1998).

Editors’ Note: The next part of the text will be in the next newsletter (Vol. 13, No. 2). The final newsletter will have the complete references.

1999 FALL CAMPOUT GET-TOGETHER AT MEETING AT FOSSIL CREEK

We couldn't have asked for better weather for our fall campout, especially when just a few weeks earlier it was really quite cold. The long, bumpy and dusty ride was all made worth it when we arrived at the Arizona Public Service (APS) Irving Power Plant facilities for our camp.

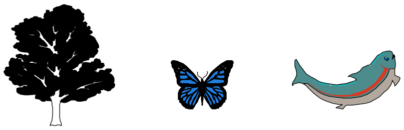
Marty Jakle, who has been very interested in Fossil Creek for some time, started out by telling us what has happened since we camped there in 1992. Mike Steward, who is the manager for the plant, gave us a tour and provided information about the site. He told us that it is on the National Registry of Historic Places. Jerry Stefferud and Steve Overby from the U.S. Forest Service told us about and the Fossil Creek system and the native fish found there; Steve informed us about the travertine deposit formations in the creek.

Our master chef, Jeff Inwood, graciously grilled hamburgers and veggie burgers for us. Along with all the other fixings we had a great dinner topped off with Marty's special sopapillas. After dinner, Mindy Schlmingen-Wilson from American Rivers brought us up to speed on the negotiations with APS, as much as she was allowed to tell us at that time.

Sunday morning, after everyone's breakfast and Marty's dishtowel coffee, everyone hiked up to the falls and to see the travertine deposits. Everyone enjoyed the midmorning to midafternoon hike. The kids played in the water and everyone just took in the beauty of it all.

As you all may or may not know by now, after our fall meeting APS has agreed in principle to restore flows to the creek (see *President's Message* page 2). You may see the press release on the American Rivers website at: *http://www.amrivers.org/sw-fossilpress.html.*

Fossil Creek. Photo by Mitchell Laidlaw, October 1999.



SPECIES PROFILE

THE GARTER SNAKES OF ARIZONA

by Jeffrey M. Howland, U.S. Fish and Wildlife Service, Phoenix

Garter snakes are perhaps the most familiar snakes to most Americans, and are among the best known to science as well. Arizona is home to five species of garter snakes, all of which depend upon riparian and other aquatic habitats to some extent. These are, in fact, the only snakes in the state that can be regarded as aquatic or semi-aquatic in their habits. Habitat use varies among species, and impacts to riparian habitats have likewise had different effects on the conservation status of each.

The garter snake genus, *Thamnophis*, is the most speciose snake genus in the United States, with about 16 currently recognized species. Another 14 or so species occur in Mexico and Central America, bringing the total to about 30. Garter snakes occur broadly across North America. Almost anywhere in the United States, at least one species can be found, and some local areas have three or four. The common garter snake, *T. sirtalis*, can be found from coast to coast and from Mexico to the Northwest Territories, making it the snake with the northernmost distribution in the New World. It is not found in Arizona.

Although garter snakes are not dangerously venomous to humans, they do have slightly enlarged teeth at the rear of the upper jaw that may function to introduce saliva that is toxic to their preferred prey. Most species of garter snakes are of moderate size. Those that exceed 3 ft (915 mm) in total length (as do all five of Arizona's species, at least occasionally) are considered large. Garter snakes tend to feed more frequently and eat smaller prey than other snakes of similar size. Diet is dominated by amphibians and fishes, though some species commonly eat invertebrates and a few even eat small mammals. Many species show a marked shift from feeding on the smaller invertebrates as juveniles to larger vertebrate prey after reaching adult size. Foraging behavior of garter snakes often involves active searching, relying mainly on vision and chemosensory cues to find prey. Some species may use ambushing techniques as an alternative.

All garter snakes are viviparous (give birth to live young rather than laying eggs), a trait common to many aquatic snake species around the world. They tend to produce large litters of relatively small young. Some populations of the common garter snake average over 30 young per litter (with some litters being much larger). In many species of snakes, individual females reproduce only once every two or three years. Most female garter snakes, on the other hand, reproduce every year. Female garter snakes typically reach sexual maturity at an age of two or three years, with males maturing perhaps a year earlier.

Garter snake predators include birds of prey, carnivorous mammals, and even large fish. Because they are relatively active in open habitats, and primarily diurnal, garter snakes cannot depend on cryptic coloration or secretive behavior to the extent that most other snakes do as mechanisms to avoid predation. A garter snake's first line of defense when a predator is encountered is usually to flee, either into thick vegetation, an underground retreat, or water. Failing to make a clean escape, a garter snake will typically strike, wiggle its tail to divert the predator's attack (away from the vulnerable head and toward the less vital tail), and exude a foul-smelling discharge from the cloaca. Specific behaviors differ from species to species, but these defensive tactics are common among snakes in general, with the last one being almost universal. Anyone who has handled a garter snake is familiar with the nasty odor invariably imparted to hands or clothing, but many other snakes exceed them in propensity to use this defense or in sheer repugnance of the exudate produced. A stressed-out garter snake may also regurgitate a recent and partially digested meal. If handled gently, all this unpleasantness usually passes within a few minutes, after which the snake may calm down and become rather tame.

Considering the status of most of Arizona's natural aquatic habitats and the species that depend upon them, three of our five species of garter snakes are doing surprisingly well. Possible reasons for their success, as well as for the more guarded status of the other two, are discussed in the following individual species accounts.

The western terrestrial garter snake (*T. elegans*) lives in moderate to high elevation lakes, ponds, stock tanks, and streams across the northeastern third of Arizona, with one disjunct population occurring as far south as the Pinaleño Mountains. This wide-ranging species has a correspondingly catholic diet, feeding on small mammals, amphibians, fishes, and invertebrates (including earthworms, leeches, slugs, and snails) to varying degrees in different areas, depending mostly on local prey availability. In Arizona, these snakes can occur at high density in montane wet meadows and streams. A study in New Mexico found substantially lower numbers of this snake in a grazed section of riparian habitat than in ungrazed livestock exclosures upstream (where bank vegetation, particularly alder and willow, was considerably thicker). Even in grazed areas, the snake appears to remain common enough that its persistence seems assured. Perhaps because this snake is a generalist, it is doing well in the face of habitat modification and introduction of non-native fishes. Ability to use temporary waters that lack non-natives may be partially responsible, but they remain present even in some lakes and streams where active programs for sport fish stocking are in effect. Time will tell if this species is able to persist in the face of increasing invasion of its habitat by non-native crayfish.

Blackneck garter snakes (*T. cyrtopsis*) are found mainly in canyons of the mountains and foothills of central and southeastern Arizona. They feed on frogs, tadpoles, and occasionally fish. These snakes can be found at substantial distances (500 m or more) from water, although the function of these excursions is uncertain and they may be of short duration. The species is fairly common and seems to be doing well, perhaps in part because they are able to thrive in stock tanks. Furthermore, the small and isolated desert canyons they inhabit are not prime areas for introduction of predatory sport fish or for the construction of large dams or other large-scale water diversions. The flashy ephemeral flows are also not conducive to invasion by many non-native species.

Western terrestrial garter snake. Photo by Jeffrey M. Howland.

Checkered garter snakes (*T. marcianus*) are found in lower elevation aquatic sites throughout southern Arizona. They live in rivers, streams, stock tanks, irrigation ditches, and other permanent waters, but also use ephemeral desert ponds. In more mesic portions of its geographic range, this species has been reported to be quite terrestrial, but in Arizona it is rarely found far from water. One Arizona study found that juvenile checkered garter snakes feed primarily on earthworms, but as adults they switch to amphibians. They eat non-native bullfrogs (both tadpoles and young frogs) as well as native toads and spadefoots. Checkered garter snakes are uncommonly encountered along the lower Colorado River. A lack of information on historical abundance makes it difficult to know whether populations in this area have declined or have always been low in density. Overall, like blackneck and terrestrial garter snakes, checkered garter snakes are doing fairly well in Arizona. All three share a tolerance for human-altered aquatic habitats and at least some degree of resistance to predation by non-native fishes and bullfrogs. They also occur with large aquatic predators elsewhere in their ranges, and may therefore not be entirely naive, in an evolutionary context, to these non-native (in Arizona) predators.

Narrowhead garter snake. Photo by Jeffrey M. Howland.

Narrowhead garter snakes (*T. rufipunctatus*) are the most highly aquatic of Arizona's garter snakes. They inhabit moderate to high elevation (up to 8000 ft, about 2500 m) mountain streams below the Mogollon Rim and in the White Mountains. They forage in rocky pools and riffles, where they feed almost exclusively on fish. In recent years, anecdotal reports of population declines have led to speculation about threats. Bullfrogs are largely absent from narrowhead garter snake habitat, but non-native fishes (such as smallmouth bass, sunfish, and non-native trout) and crayfish have decimated native fish faunas in many streams and may also feed on juvenile garter snakes. Narrowhead garter snakes can probably persist with trout alone, but the combination of multiple non-native predators and accompanying reduction in native prey may prove overwhelming. Anecdotal reports of intentional killing by anglers and other recreationists seem unlikely to account for rangewide declines, especially along more remote stretches of mountain streams, but may contribute to the demise of local populations.

The Mexican garter snake (*T. eques*) is, as its name implies, a predominantly Mexican species, but its range extends into southern Arizona and New Mexico. Diet consists chiefly of amphibians and fish, though large adults take small mammals and juveniles will eat leeches and other invertebrates. Mexican garter snakes are usually found in cienega habitats, but well-vegetated stock tanks and backwaters of low gradient streams and rivers with well-developed bank vegetation are also acceptable. Loss of cienegas and introduction of predatory bullfrogs (which are capable of eating all but the very largest adult snakes) have led to the near extirpation of this species from the United States. It is unclear why Mexican garter snakes seem unable to withstand predation by bullfrogs while checkered garter snakes may flourish in the same situation, even to the point of replacing Mexican garter snakes at some sites. It seems likely that patterns of habitat use place it in more frequent contact with bullfrogs. Perhaps checkered garter snakes spend less time near the water's edge, where bullfrogs wait for prey, or more time in thicker vegetation where they are less vulnerable. Or perhaps they are more active at night or at other times when bullfrogs may be less successful at capturing them. Bullfrogs are active at night, but seem to be more effective predators of diurnally active animals. A recent study in southeast Arizona found that juvenile checkered garter snakes are largely terrestrial until they reach a length of about 15 inches (400 mm), by which time they are less vulnerable to bullfrog predation. Mexican garter snakes are highly aquatic from birth. Whatever the reasons, Mexican garter snakes are a strong candidate to become the first species lost from Arizona's rich reptile fauna.

While the last two species discussed have become difficult to find, the other three remain fairly easy to observe. Identification to the species level can be difficult, but with minimal study of a field guide it is easy to tell garter snakes (as a group) from all other snakes in Arizona. If you keep your distance, they are more interesting to watch than most other snakes, simply because they are more active and more tolerant of the presence of a human observer. So next time you're around water, keep your eyes open and you may see a garter snake, and be fortunate enough to watch it go about its everyday activities.

Mexican garter snake. Photo by Jeffrey M. Howland.

LEGAL ISSUES OF CONCERN

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SIGNIFICANT LEGAL DEVELOPMENTS REGARDING WATER RIGHTS IN ARIZONA: THE ARIZONA SUPREME COURT'S RECENT OPINION IN THE GILA RIVER ADJUDICATION

As part of the ongoing *General Adjudication of All Rights to Use Water in the Gila River System and Source*, the Arizona Supreme Court recently provided its eagerly awaited opinion on two significant water rights issues that needed deciding before the adjudication could continue *(Ariz. Sup. Ct. Opinion*, WC-90-0001-IR (*En Banc* November 19, 1999) ["the Opinion"]). The issues addressed in this "interlocutory review" were:

- Do federal reserved water rights, i.e., rights held by the Indian Tribes, extend to groundwater?
- Are federal reserved rights holders entitled to greater protection from groundwater pumping than are water users who hold only state law rights?

Briefly put, the Court answered both questions in the affirmative for a number of reasons discussed below.

BACKGROUND

The Salt River Valley Water Users Association (SRVWUA) initiated the Gila River adjudication in 1974 by filing a petition with the Arizona State Land Department (SLD) for an adjudication of water rights in the Salt River. A change in state law subsequently assigned jurisdiction over water rights adjudications to the superior courts. The original petition by SRVWUA was consolidated in the Maricopa County Superior Court with other petitions filed for general adjudications of water rights in the Salt, Verde, and San Pedro Rivers, and later, the Upper Agua Fria, Upper Gila, Lower Gila, and Upper Santa Cruz Rivers. In 1988, the trial court issued rulings on a number of questions concerning the relationship of groundwater and surface water. In response, petitions were made by various parties to the Arizona Supreme Court for interlocutory review, i.e., a request that the Court decide these issues before the case move on. On December 11, 1990, the Court agreed to review six issues. The Court addressed the first issue in 1992 and held that the Pretrial Order's provisions for filing and service satisfied the due process guarantees of the U.S. and Arizona Constitutions *(Gila River I*, 171 Ariz. 230, 232 (1992)). The second issue was addressed in 1993, whereupon the Court affirmed a test for determining when underground water is appropriable under state law *(Gila River II*, 175 Ariz. 382 (1993)). The third issue, concerning the appropriate standard to be applied in determining the amount of water reserved for federal lands, was recently argued before the Court in late November 1999. Issues 4 and 5, the subjects of the Court's opinion released November 19, 1999, are discussed below.

WHETHER FEDERAL RESERVED RIGHTS EXTEND TO GROUNDWATER

In the Opinion, the Arizona Supreme Court held that when federal reservations are created, the U.S. implicitly intends to reserve sufficient water, including groundwater, to meet the reservation's future needs. This holding is a significant interpretation of the reserved water rights doctrine which was adopted by the U.S. Supreme Court in the early years of the last century. The reserved water rights doctrine is often referred to as the *Winters* doctrine, when discussed in relation to tribal water rights, because of the landmark case *Winters v. U.S., 207 U.S. 564 (1908)*. In *Winters*, the Supreme Court enjoined upstream settlers in Montana from diverting Milk River waters from flowing to the Fort Belknap Indian Reservation, despite the settlors' claims that they had priority to the water under Montana's prior appropriation law. In doing so, the Court concluded that the federal government had implicitly reserved sufficient water to accomplish the reservation's purpose when the reservation was created. The Supreme Court set out the doctrine in a later case:

> [*W*]*hen the Federal Government withdraws its land from the public domain and reserves it for a federal purpose, the Government, by implication, reserves appurtenant water then unappropriated to the extent needed to accomplish the purpose of the reservation. In so doing the United States acquires a reserved right in unappropriated water which vests on the date of the reservation and is superior to the rights of future appropriators.*

(*Cappaert v. U.S.*, 426 U.S. 128, 138 (1976)). The doctrine serves as an exception to Congress' deference to state water law (*Id.* at 145). In *Cappaert,* the Supreme Court upheld the Ninth Circuit's injunction against a private landowner's attempt to drill wells on ranch land that would draw water from the same source of groundwater used by an endangered fish that existed on neighboring National Monument land. The Court did not reach the issue of whether a reserved right to groundwater exists – the very issue (issue #4) that the Arizona Supreme Court faced.

To determine whether a reserved right to groundwater exists, the Arizona Supreme Court first looked to *Winters* and found that case supported an extension of federal reserved rights to groundwater because GRIC required groundwater for its future survival in much the same way the Fort Belknap Reservation depended on the availability of water from the Milk River to water future crops. The Arizona Supreme Court found further support for this viewpoint from the U.S. Supreme Court's declaration in *Arizona v. California* that it was "impossible to believe" that those who created the Colorado River Indian Reservation did not contemplate the use of Colorado River water on the Reservation considering the desert nature of the land (*Opinion at* 19, *citing* 373 U.S. at 599). Moreover, the Arizona Supreme Court found that the *Cappaert* court's decision to consider surface and groundwater as integral parts of a hydrologic cycle meant that federal reserved rights law would also identify both water sources as protected sources (*Opinion at* 20). In addition, the court found that state law was inadequate to protect the Reservations from the groundwater depletion due to off-reservation pumping. The court pointed to *Gila River Pima-Maricopa Indian Community v. U.S.,* 9 Cl. Ct. 660 (1986) where the court found that federal inaction and lack of tribal resources enabled off-reservation developers to pump aquifers underlying some Indian reservations dry before the Indians had exercised their rights to that groundwater for irrigation purposes (*Opinion at* 24-25).

Thus, the Arizona court held that the federal reserved rights doctrine applies to groundwater, with the significant caveat that this reserved right is only found where other waters, e.g, Central Arizona Project (CAP) water, are inadequate to accomplish the purpose of the reservation (*Opinion at* 25). The issue of CAP water availability allows for a brief discussion of recent events surrounding the Gila River Indian Community's (GRIC's) ongoing efforts to have the Bureau of Reclamation (Bureau) build the Pima Lateral Feeder Canal – a half-mile long open canal connecting CAP to the community's irrigation system. The Canal would allow GRIC to divert 30,000 acre-feet of CAP water onto the reservation for agricultural purposes. In 1989, the Bureau agreed to build the canal and initiated Endangered Species Act (ESA) consultation with the Fish and Wildlife Service (FWS). The FWS draft Biological Opinion (BO) concluded planned CAP water deliveries to GRIC and others would jeopardize a number of endangered Colorado River fish. FWS and the Bureau agreed on Reasonable Prudent Alternatives (RPA) that they claimed would protect the fish. Subsequently, both the Central Arizona Water Conservation District (CAWCD) and the Southwest Center for Biological Diversity (now, Center for Biological Diversity) sued FWS and the Bureau claiming the RPA's were inadequate. On September 30, 1999, a Hawaiian federal district judge upheld the scope of the FWS BO and RPAs (*Southwest Center for Biological Diveristy v. Babbit*, 97-474 PHX DAE, (D. Ariz. 1999)). Thus, GRIC faces one less hurdle in its effort to have the Pima Lateral Feeder Canal built. Funding, namely, obtaining an appropriation from Congress for the Canal, is another matter.

THE LEVEL OF PROTECTION FEDERAL RESERVED RIGHT HOLDERS MAY CLAIM AGAINST OFF-RESERVATION PUMPERS

Under Arizona law, a surface water user generally may not protect its source of surface water from depletion by groundwater pumping unless the pumping draws from “subflow”. Subflow is defined as “those waters which slowly find their way through the sand and gravel constituting the bed of the stream, or the land under or immediately adjacent to the stream, and are themselves a part of the surface stream” *(Southwest Cotton*, 39 Ariz. 65, 96 (1931)).

According to the Arizona Supreme Court, federal reserved water users are not so constrained, and the Court upheld the Superior Court’s 1988 holding that federal reserved rights apply not only to surface water and subflow, but also to groundwater. Under these holdings, federal reserved water rights holders may prevent off-reservation groundwater pumping that “significantly diminishes” the availability water that could satisfy reservation purposes. Thus, federal reserved rights holders enjoy greater protection from groundwater pumping then do holders of state law rights *(Opinion at* 28-29). The Arizona court found that his conclusion was necessarily reached taking into consideration the *Winters* case and its federal progeny which require groundwater remain available to accomplish the purpose of a reservation (*Id. at* 29-31).

GROUNDWATER PUMPING RESTRICTIONS

The court considered it “premature” to address the issue of whether its order required immediate groundwater pumping restrictions in the area surrounding the reservations – a major concern among the housing development community and other industry sectors. However, the court did suggest that in some instances the provisions of the state’s 1980 Groundwater Management Code could serve to adequately protect reservations against groundwater depletion and forestall the need for groundwater pumping restrictions. For instance, reservations located within areas of the state considered *active management areas* (AMAs) under the Code might be adequately protected against groundwater depletion. Reservations outside the five AMA’s that are currently administered by the Arizona Department of Water Resources (ADWR) (Phoenix, Pinal, Prescott, Santa Cruz and Tucson) may not, the court stated, provide an adequate degree of protection and would be subject to pumping restrictions. In any event, the establishment of such restrictions would likely require an amendment to the Groundwater Code by ADWR, although some municipalities are reportedly entering into their own agreements with GRIC to restrict groundwater pumping. The status and legality of such agreements remains uncertain at this time.

Since much of the federal land in Arizona is held in trust for the Indian tribes, the Gila River general stream adjudication has the potential to profoundly affect Arizona’s water users – be they groundwater or surface water users. The Arizona Supreme Court’s opinion bears this out. Water attorneys throughout the West are reading this opinion with great interest. One can expect that the Court’s decision to extend federal reserved water rights to groundwater, and to afford greater protections to federal reserved rights holders than those available to water users holding only state rights, will reverberate throughout the West for some time to come.

The Arizona Riparian Council (ARC) was formed in 1986 as a result of the increasing concern over the alarming rate of loss of Arizona's riparian areas. It is estimated that <10% of Arizona's original riparian acreage remains in its natural form. These habitats are considered Arizona's most rare natural communities.

The purpose of the Council is to provide for the exchange of information on the status, protection, and management of riparian systems in Arizona. The term "riparian" is intended to include vegetation, habitats, or ecosystems that are associated with bodies of water (streams or lakes) or are dependent on the existence of perennial or ephemeral surface or subsurface water drainage. Any person or organization interested in the management, protection, or scientific study of riparian systems, or some related phase of riparian conservation is eligible for membership. Annual dues (January-December) are $15. Additional contributions are gratefully accepted.

This newsletter is published three times a year to communicate current events, issues, problems, and progress involving riparian systems, to inform members about Council business, and to provide a forum for you to express your views or news about riparian topics. The next issue will be mailed in May, the deadline for submittal of articles April 15, 2000. Please call or write with suggestions, publications for review, announcements, articles, and/or illustrations.

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CALENDAR

Information Transfer Forum on Riparian and Stream Restoration in Arizona, March 22-23, 2000, Crowne Plaza Hotel, Phoenix, AZ. Arizona Water Protection Fund Commission is providing an opportunity for grantees to share information about restoration techniques. For more information or questions, contact: Irmalisa Horton at (602) 417-2400 x7016.

Southwest River Management and Restoration: Nonstructural Approaches conference, April 3-5, 2000, Crowne Plaza Hotel, Phoenix, AZ. Conference will explore the increasingly valuable role of watercourses in our community. For more information contact Valerie Swick at (602) 506-4872.

Upper Gila River Watershed: Conservation and Management, May 12-13, Eastern Arizona College, Safford, AZ. Arizona Riparian Council's 14th meeting concerning Gila River watershed and other riparian issues. Contact Cindy Zisner for more information at Cindy.Zisner@asu.edu or (480) 965-2490. Call for papers is available on our web site http://aztec.asu.edu/ARC/2000call.htm.

Third Conference on Research and Resource Management in the Southwestern Deserts, May 16-18, 2000, InnSuites Hotel, Tucson, AZ. Interagency collaboration in land use, research, resource management and interpretation. For more information please contact Bill Halvorson at 520-670-5001.

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