Eye on Nature

TEXAS PARKS & WILDLIFE

SPRING 2010 **A publication of the Wildlife Division — *Getting Texans Involved***

Hidden Treasures of the Texas Hill Country

By Kathleen O'Connor

The Texas Hill Country usually brings to mind gently rolling hills, oak-juniper woodlands and a multitude of water- and land-based recreational activities for even the most finicky outdoor enthusiast. But there's far more to the Hill Country than meets the eye. Beneath our feet is a subterranean universe where the ever-present struggle for life plays out among enigmatic and mysterious species that characterize this alien world. First, a little background information on how this all came to be. During the Cretaceous Period (about 145–65 million years ago), Central Texas was covered by a shallow sea filled with a multitude of life forms, many of which were comprised of calciferous skeletons or shells. These formed deposits on the sea floor after the animals died. As layers and layers of these accumulated through vast stretches of time and compression, limestone was formed. Then about 25 million years ago, after the sea had already receded for the last time, the Edwards Plateau underwent a series of uplifts as a result of tectonic motion. The permeable Edwards limestone was then carved out like Swiss cheese, thanks to the intake of rainwater through surface fissures and fractures. This type of landscape, created by the dissolution of limestone and characterized by fissures, sinkholes and caves, is called karst.

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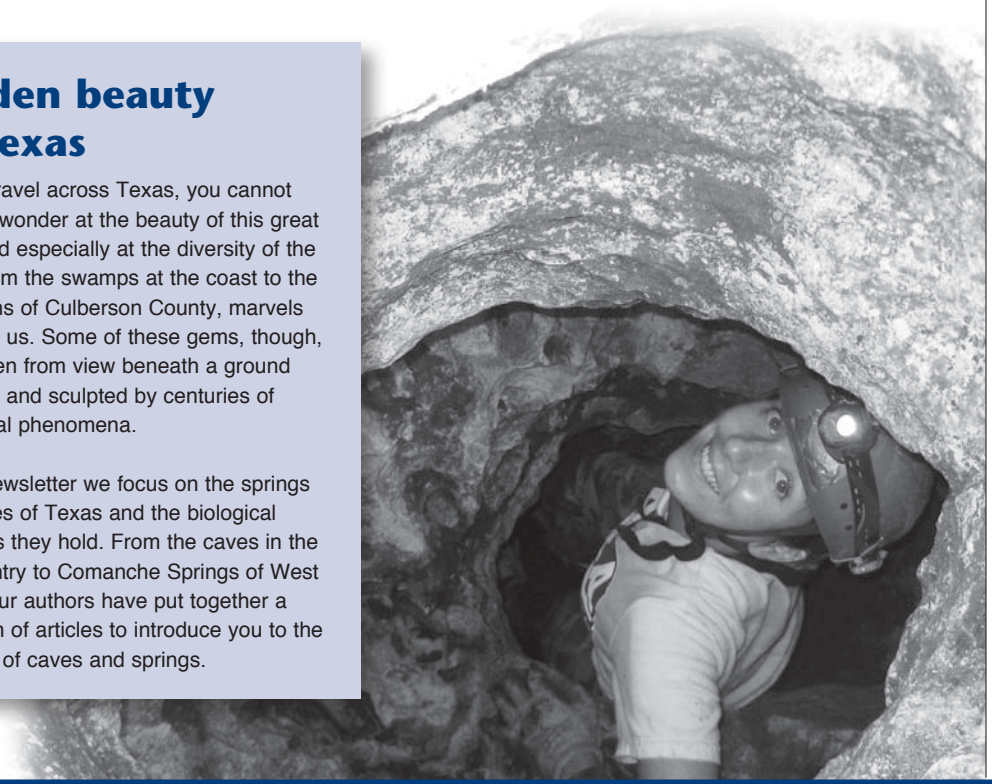
Hidden beauty of Texas

As you travel across Texas, you cannot help but wonder at the beauty of this great state, and especially at the diversity of the land. From the swamps at the coast to the mountains of Culberson County, marvels surround us. Some of these gems, though, are hidden from view beneath a ground fractured and sculpted by centuries of geological phenomena.

In this newsletter we focus on the springs and caves of Texas and the biological treasures they hold. From the caves in the Hill Country to Comanche Springs of West Texas, our authors have put together a collection of articles to introduce you to the wonders of caves and springs.



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"To manage and conserve the natural and cultural resources of Texas and to provide hunting, fishing and outdoor recreation opportunities for the use and enjoyment of present and future generations."

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ADDRESS CHANGES: For address changes, or to be added or removed from our mailing list, please contact **mark.klym@tpwd.state.tx.us**. We look forward to providing the information you need to understand, appreciate, manage and conserve the natural resources of Texas for the use and enjoyment of present and future generations.

*[**Hidden treasures of the Texas Hill Country**, continued from page 1]*

The unique conditions found in caves, along with years of isolation, have produced a fascinating and rich biota. Here we find species with adaptations that perfectly reflect their rich, subterranean history-long appendages for greater sensory reach, absence of eyes and pigmentation, and reduced metabolic and reproductive rates. It is theorized that these cave-adapted species originated from surface populations that may have retreated into caves to escape inhospitable conditions above ground. Geologic and hydrologic barriers may have contributed to increased isolation which, in turn, led to greater adaptation to life underground. In Central Texas, this has produced a rich and diverse faunal assemblage found nowhere else in the world. These cave-adapted species that cannot survive outside the cave environment are known as troglobites. Texas members of this group include some spiders, beetles, millipedes, harvestman, salamanders, isopods and catfish, among others. But they aren't alone. Other animals play a part in this underground community as well. Troglophiles are animals that are found in caves but are not necessarily tied to it for survival. They may be found in similar habitats outside of the cave environment, such as in the leaf litter or under logs and rocks. Some salamanders and scorpions are included in this group. Trogloxenes, such as bats and crickets, will utilize caves as a temporary shelter but still spend a substantial amount of their time on the surface. It is upon these trogloxenes and other surface community components, such as leaf litter and organic debris, that the cave ecosystem is most dependent on for nutrient and energy input. In addition to providing nutrients, the surface plant community also acts as a buffer, protecting the karst ecosystem against perturbations to temperature and moisture regimes required by these troglobites. Surface communities are significant for the cave crickets, too. They are known to venture from the cave at night in order to forage for food, sometimes over 100 meters from the cave entrance. When they return, they bring an energy source with them in the form of eggs, guano and also their carcasses when they die. This, in turn, serves as a food source for resident troglophiles and troglobites in the cave. Consequently, cave crickets can be considered a keystone species within this unique ecosystem. For all of these reasons, protection of the vegetative surface communities surrounding the cave entrance is of vital importance.

The conservation of karst terrain is important, particularly in light of another example found here in Central Texas: the Edwards Aquifer. This underground water source is located on the eastern edge of the Edwards Plateau and provides water and recreation to close to 2 million people.

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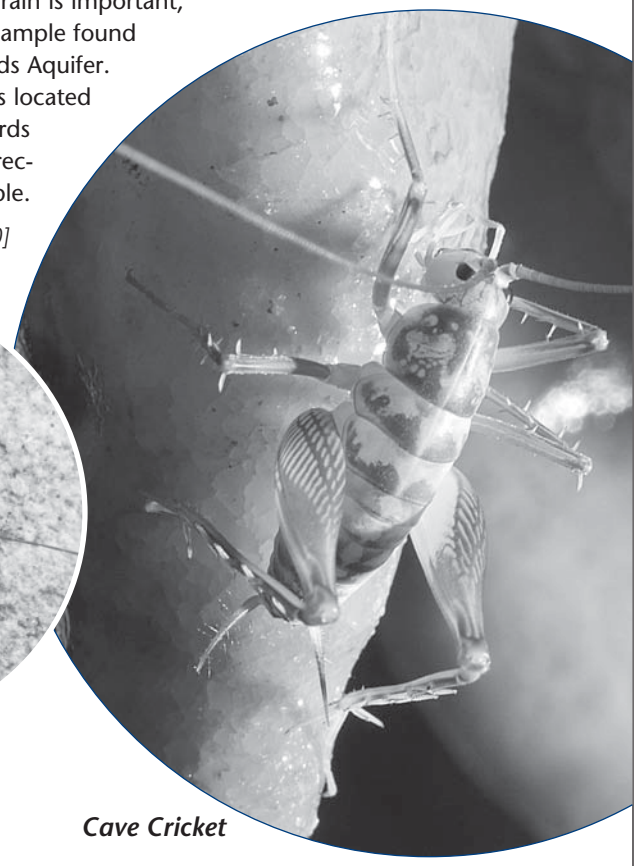

Cave Cricket

The Importance of Springs

By Ryan McGillicuddy and Gary Garrett

As you travel west across Texas (especially once you enter the Edwards Plateau and Trans-Pecos ecoregions) surface water becomes much less abundant, making springs a vital component of the landscape for plants, animals and humans alike. Standing out like oases, these springs have influenced human settlement patterns, land uses and routes of transportation since the first people arrived in Texas several thousand years ago. They are inextricably tied to the culture and history of our state. Likewise, springs have had profound effects on the development of biological communities, and are host to a diverse array of unique fish species.

Fish in general are limited in their options of where they can live. Unlike humans and many terrestrial species that can move across the landscape in search of suitable habitats, fish are constrained to where the water can take them, and are often further restricted by physical barriers within waterways, such as dams. For aquatic species adapted to spring environments these constraints can be even more extreme. For example, some fish that live in spring-fed waterways require clean, clear water with temperatures that remain relatively constant. These conditions might only be found in specific areas within a given watershed, preventing these fish from migrating to other areas of like habitat and mingling with other populations. Such habitat barriers can keep populations isolated, leading to specialized adaptations and genetic variations, even in areas not geographically distant from one another. When a species is found exclusively in one area or a very specific range, it is referred to as an *endemic* species.

Because the ranges of many spring-dependent fish species are often very small and the available habitat limited, they are very vulnerable to pollution and habitat alteration. By far the largest threats to these fish in Texas are habitat loss due to the over-pumping of groundwater and the associated reductions in spring flows, and hybridization with other fish species. Unfortunately, many unique species and their surrounding habitats have been severely impacted in the past century.

The San Marcos Springs are the second-largest spring system in Texas and form the headwaters of the San Marcos

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Texas has been called a land of springs. By working together we can make sure that future generations will know it this way too.

Blind Monster

By Andy Gluesenkamp

A blind monster lives under the City of San Marcos. It spends its entire life wandering the water-filled voids that comprise the San Marcos pool of the Edwards Aquifer. It detects the presence of a hapless victim by chemical cues and minute vibrations and then stalks it with terrifying patience. Once within range, the blind monster inhales its prey in one violent gulp. Like Moby Dick, this creature has no natural predators. Man is its only threat.

The Texas blind salamander (*Eurycea rathbuni*) was formerly described as *Typhlomolge rathbuni* (Typhlomolge means "blind monster") in 1896. Over a century later, it is one of the most famous amphibians on earth. It was one of the first species placed on the Federal Endangered Species list and, despite the fact that it has long fascinated scientists and the public alike, few people have ever seen one and little is known about its life history or population status.

Other closely related species have been discovered living elsewhere along the Balcones Fault Zone. The Blanco blind salamander (*Eurycea robusta*) is known from a single specimen collected in a hand-dug crevice in the bed of the Blanco River in 1951. The Austin blind salamander (*Eurycea waterlooensis*) was described in 2000 and is known only from Barton Springs in Austin. More recently, a fourth species was discovered in wells and springs in New Braunfels. All of these species are thought to inhabit aquifer habitat, and only rarely do hapless individuals emerge from large springs emanating from aquifer sources. All members of the subgenus Typhlomolge are blind and have shovel-shaped heads and long spindly legs. They have greatly reduced pigmentation which gives them a pearlescent appearance. Compared to related surface species found in some of the same springs, they are giants. Members of this group may be three times the size of surface congeners. This large size likely reflects a release from strong selective pressures associated with surface living.

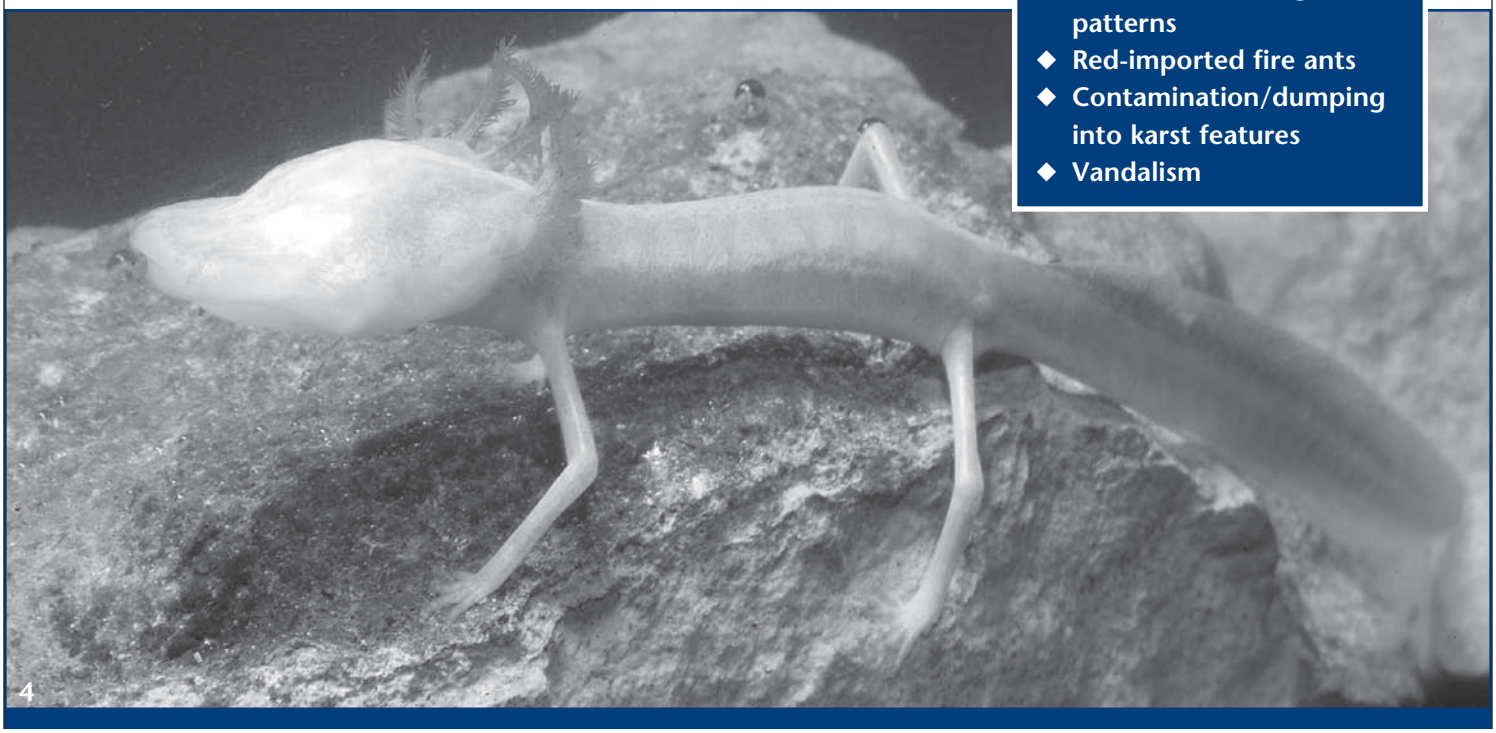
All blind salamanders are totally dependent on groundwater. Therefore reduction in the quality and quantity of water in the Edwards Aquifer poses the greatest threat to their existence. Some of the greatest threats: heedless development and water mining are best addressed though a suite of efforts including legislation, public education and conservation incentives. Protecting groundwater is an enormous challenge both in terms of the scale of the endeavor and in terms of political appeal and public sentiment. However, these organisms are perhaps the most striking examples of the incredible biodiversity found in Texas and are a treasure that, hopefully, will be shared with future generations.

Andy Gluesenkamp is the herpetologist working with the Wildlife Diversity Program out of the Austin headquarters for Texas Parks and Wildlife Department.

DID YOU KNOW?

Threats to listed Karst Invertebrates:

- Urban development
- Filling in and the collapse of karst features
- Alteration of surface community
- Alteration of surface and subsurface drainage patterns
- Red-imported fire ants
- Contamination/dumping into karst features
- Vandalism



*[**The importance of springs**, continued from page 3]*

River. Here the San Marcos gambusia (*Gambusia georgei*), a small fish found only in these headwaters, is threatened by reduced spring flows and the introduction of non-native species that may prey on them, replace or destroy aquatic vegetation used as habitat, or compete with them for food. The last San Marcos gambusia was collected in 1983 and may already be extinct.

Two more species, the Comanche Springs pupfish (*Cyprinodon elegans*) and the Pecos gambusia (*Gambusia nobilis*) were extirpated (completely removed) from Comanche Springs in 1955 when the springs first went dry, a result of severe drought coupled with increased demand for groundwater to irrigate agricultural fields in the area. Comanche Springs was one of the largest springs in Texas (more than 22 million gallons per day), but now only flows occasionally when there is no irrigation demand. People also suffer when their water sources vanish. Farmers who depended on surface irrigation water from Comanche Springs lost their livelihood when the springs went dry. Both fish species still survive in the Balmorhea area in waters that emerge from San Solomon and other smaller springs, as well as in irrigation canals in the area; however, their existence remains tenuous due to diminishing spring flows.

The Amistad gambusia (*Gambusia amistadensis*), a species that was found only in Goodenough Springs, was extirpated after the construction of Amistad Reservoir in 1968 submerged the area under 70 feet of water. Goodenough Springs were the third-largest in Texas prior to their inundation. Refuge populations of the Amistad gambusia suffered from hybridization and the species was declared extinct in 1987.

The loss or imperilment of such species forces us to ask a number of questions. For many people the first one that comes to mind is, "Why should I care?" This is a very natural question to ask, especially when the value of a species may not be immediately apparent, perhaps because it is small or not exploited for commerce or recreation. However, there are numerous reasons to preserve and protect such species, including fish found in the spring-fed streams of Texas.

Many small species, such as the gambusia and pupfish mentioned above, serve to inform us about the overall health and well-being of a specific habitat or ecosystem. These are often referred to as *indicator species*. If a species that is specifically adapted to a particular location does not seem to be faring well, it can offer us insight into the biological condition of the watershed at large.

Maintaining diversity is another reason for protecting such species. All organisms in an ecosystem are part of a complex web of relationships, with species depending on one another for their survival. Small fishes may feed on decomposing organic matter, algae and small invertebrates. They are themselves eaten by larger fish and reptiles, which in turn are eaten by birds, small mammals and game animals that likewise play their own integral role in the ecosystem. Maintaining a diverse array of species helps to ensure the health of the entire system, while removing even small parts of the web may have a detrimental effect.

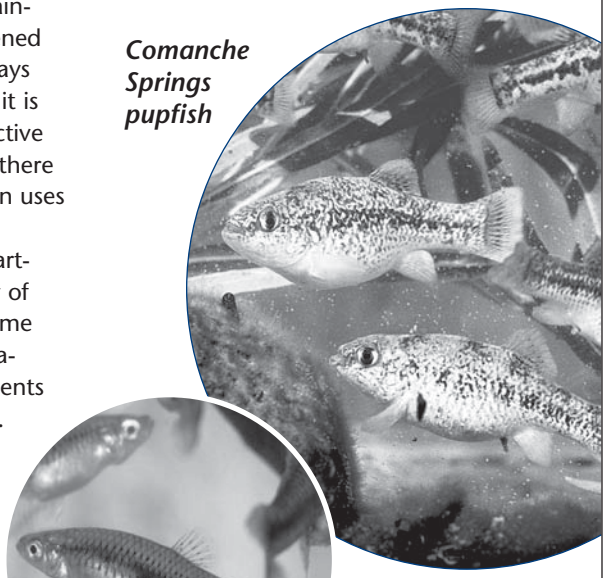
Ensuring that there is adequate water for these species to survive also ensures that there will be water for human uses. If water is over-pumped or poorly managed, spring flows may cease, effectively turning off the faucet that supports the aquatic systems we rely on for irrigation, water supply and recreation. While in extreme circumstances federal regulators may mandate that minimum spring flows be maintained for the survival of a threatened or endangered species, this is always an undesirable outcome. Instead, it is better for all water users if a proactive approach can be taken to ensure there is enough water to support human uses and our natural heritage alike.

Texas Parks and Wildlife Department has worked to restore many of these habitats and resolve non-game species problems through cooperative programs with local governments and especially private landowners. This has been exemplified by the creation of a "natural" ciénega (desert wetland) for Comanche Springs pupfish and the Pecos gambusia at Balmorhea State Park within the boundaries of the original, natural ciénega. As a result, the native flora and fauna have flourished. This location now provides a natural habitat and contains the largest known concentration of Comanche Springs pupfish. TPWD is now constructing a second ciénega at Balmorhea State Park to be completed in Spring 2010.

Another example of this collaborative type of approach is the Edwards Aquifer Recovery Implementation Program. The waters of the Edwards Aquifer support numerous unique plant and animal species threatened by the reduction of flows due to over-pumping and drought. This voluntary, multi-stakeholder initiative has drawn together a diverse group of participants who are currently developing a program that will balance water use and the needs of federally listed species.

Involving individuals and local governments in conservation of species and their habitats increases the likelihood of achieving long-term benefits for natural resources as well as protection of these resources for the public. Texas has been called a land of springs. By working together we can make sure that future generations will know it this way too.

Ryan is a conservation ecologist working with the Inland Fisheries Division of Texas Parks and Wildlife Department in Austin. Gary is Program Director of Watershed Policy and Management working out of Mountain Home, Texas.



Comanche Springs pupfish

Pecos gambusia

On Land Management and Texas Springs

By Chad Norris

Springs are recognized as valuable ecological, natural and cultural resources. They are an important natural feature that played a major role in the lives of early inhabitants and settlers, determining the location of trails, providing power for mills and supplying water for domestic, municipal, agricultural and recreational uses. The unique aquatic and wetland habitats formed by springs represent the interface between hypogean (subterranean) and epigean (surface water) habitats. These habitats are recognized for their unique biota that often includes rare, endemic and relict species. The presence of such species is often owed to the hydrologic stability displayed by many springs in terms of the quantity and quality of water discharged over time. Because of their relative stability (as compared to streams and reservoirs), springs are also important in keeping some of Texas' aquatic and aquatic-dependent species common by providing baseflows to rivers and streams and serving as isolated refuges during environmental extremes. Springs also often maintain downstream aquatic and riparian habitats, enhance and/or sustain surface water supplies, among other benefits.

Many aquatic species are adapted to and have specific requirements related to natural flow regimes. Springs are an important component of the natural flow regime in many river basins because they provide important baseflows and in some cases contribute to freshwater inflows to bays and estuaries. Baseflows sustain aquatic and aquatic-dependent ecosystems during periods of drought, including instream, riparian and wetland habitats. The role of wetland and riparian habitats in maintaining healthy aquatic ecosystems by filtering sediments and pollutants from water, attenuating floodwaters, controlling erosion, and providing high quality wildlife habitat cannot be overstated. Because springs are often the only perennial source of surface water, especially in arid regions, maintaining springflows is an important component of conserving these vital habitats.

While recognizing that springflows had declined considerably, Gunnar Brune (1981) estimated the total flow of Texas' springs to be in excess of 4,132 cubic feet per second, or almost three million acre-feet per year (AFY). This volume of water equals about 33 percent of the estimated nine million AFY of total surface water available for use in 2010 and constitutes a significant contribution to the surface water supplies of the state. Because surface water availability analysis in Texas is generally based on historical streamflows, reductions in springflows may reduce actual streamflows to levels below that predicted. During extended drought conditions, this could have a significant impact on the availability of surface water for municipal, industrial, agricultural and other uses.

Texas Springs

Texas springs are distributed in clusters from the eastern portion of the Panhandle, the southwestern portion of the Big Bend region, in a band that follows the Carrizo-Wilcox Aquifer from South Central Texas northeasterly towards Texarkana, with the highest concentration of springs occurring throughout the Edwards Plateau. In general, the density of springs appears greatest in headwater regions and is remarkably low in the lower reaches of large river basins. This may be due to physiographic differences between headwaters and lower reaches of river systems, but may also be the result of an incomplete dataset.

The headwaters of many Texas rivers, including the Colorado, Llano, Guadalupe, Blanco, Medina, Frio, Sabinal and Nueces are formed by springs that drain the Edwards Plateau of South Central Texas. The karst terrain of this region promotes groundwater-surface water interactions and is ideal for spring development. Nowhere in the state are springs more important for sustaining aquatic habitats than in the Edwards Plateau Ecoregion. This ecoregion has the highest degree of endemism for animal and plant species in the state and also has the highest concentration of springs. Of the springs identified in the state, the majority (about 40 percent), including the 15 largest springs, issue from the Edwards and associated limestones that underlie the Edwards Plateau Ecoregion.

While large (10–100 cfs average discharge) to very large springs (>100 cfs average discharge), such as Comal, San Marcos, Barton and San Felipe springs, likely account for a large proportion of the total flow of Texas' springs, the importance of individual smaller springs cannot be overstated. Based on analysis of available discharge measurements, a majority (>80 percent) of Texas' springs are very small (0.001 to 0.01 cfs) to moderately large (1 to 10 cfs) in size. While the extent of habitat they support at the spring orifice may appear small, the cumulative flow from these small to moderately large springs often composes a significant portion of streamflows, especially during drought.

Similarly, the biological importance of a particular spring is not determined by the volume of flow produced but appears to be more affected by the persistence of flow. Many rare and endemic Texas species are found in spring habitats that display relatively low flows (0.01 to 1.0 cfs) and support limited habitat. In many cases, such as environmental assessments associated with water planning and development,

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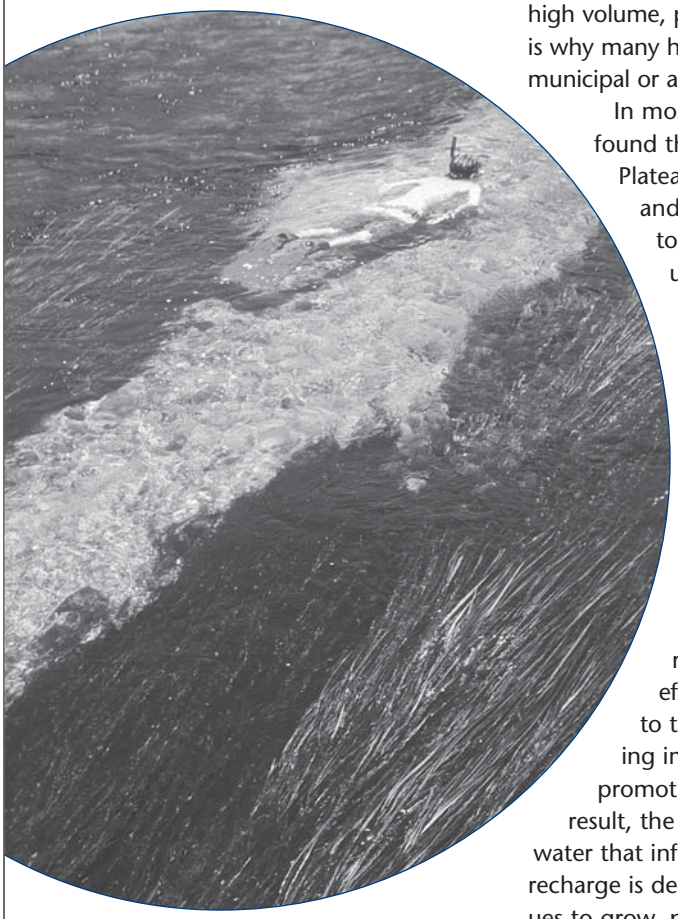
[***On land management and Texas springs***, *continued from page 6]*

these springs are thought of as insignificant. Smaller springs may be relatively insignificant in terms of water volume produced, but the habitats they sustain harbor a disproportionately high number of rare and endemic species, and the cumulative effect of their flow is key to perennial streams in the Texas Hill Country, making them a high conservation priority.



Threats to Texas Springs

As Texas' population grows, demands on land and groundwater resources also increase. Because the loss and decline of Texas springs has been well documented, many are concerned about potential impacts to springs. Primary threats to spring habitats and their associated biota include groundwater pumping, development within recharge zones, and poor land management practices, among others.

The utilization of groundwater resources results in increased capture of local recharge and/or withdrawal of groundwater from storage. Groundwater withdrawals associated with agricultural and municipal uses have impacted many of our states' largest springs (i.e., San Antonio, Comanche and Phantom Lake springs among others). Such large springs are generally recharged by water that has infiltrated at various locations, sometimes originating great distances from the spring source. Such extensive underground flow systems typically produce high volume, persistent springs, which is why many have been tapped into as a municipal or agricultural water source.

In most cases, smaller springs found throughout the Edwards Plateau have localized recharge and flow zones, often limited to the area immediately upslope of the spring. For these springs, land management practices in recharge zones play an important role in maintaining the quantity and quality of water produced by the springs.

Development and/or degradation within recharge zones and zones that contribute to recharge, in many cases, effectively reduces recharge to the aquifer by increasing impervious cover and/or promoting surface runoff. As a result, the quantity and quality of water that infiltrates into the aquifer as recharge is decreased. As Texas continues to grow, proper land management practices in recharge and contributing zones will become increasingly important for maintaining the quantity and quality of springflows.

Land management practices such as grazing, farming and brush clearing can affect springs. For example, overgrazed rangelands promote soil compaction that can effectively reduce recharge to aquifers by impeding the downward movement of water and increasing surface runoff. Plowing and clear-cutting on steep hillsides can cause severe erosion that results in sedimentation and reduces stream shading and organic inputs (i.e., leaves, woody debris, etc.) to spring habitats. Livestock grazing at springs and on streambanks often results in trampling of riparian habitats, which destabilizes banks and increases erosion. Sedimentation from erosion can impact spring habitats by burying the spring orifice and reducing both the quantity and quality of springflows.

One land management practice that has gained much attention over the years is the removal of woody plants (primarily Ashe juniper, which is commonly referred to as cedar in Texas) or shrubs that have encroached on historical rangelands. As mentioned previously, the loss and decline of Texas springs over the last century has been well-documented. During this period, groundwater pumping greatly increased and woody plant cover has increased significantly. While intense groundwater pumping has been proven to be the cause of reduced springflows at particular springs (e.g., Comanche and San Antonio springs), the effects of woody plant encroachment on springflows is less clear.

There are numerous accounts of rejuvenation of Texas springs after woody plant cover was reduced. Perhaps the most publicized example of this is the Bamberger Ranch in Blanco County where springs were seemingly rejuvenated after reducing grazing, clearing Ashe juniper and establishing native grasses. While similar stories have been reported throughout the Texas Hill Country, evidence to support claims that springflow increases resulted from Ashe juniper removal are mainly anecdotal.

Studies investigating the connection between woody plant cover removal and springflows in Texas have had somewhat differing results. Perhaps the first study that reported an increase in springflow following Ashe juniper removal was performed on an eight-acre watershed catchment in the Seco Creek watershed. The author reported that springflow increased from 11.8 liters/minute (l/min) to 14.3 l/min following Ashe juniper removal. This study is commonly cited as proof that Ashe juniper removal leads to increased water yield. However, the report does not describe the methodologies, calculations and assumptions used in the study. Because there are many

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[***On land management and Texas springs***, *continued from page 8]*

factors that affect springflows, including antecedent rainfall and groundwater levels as well as vegetation that establishes in place of Ashe juniper, the results of the study should be viewed as inconclusive.

Subsequent studies on the effect of Ashe juniper removal on springflows have had varied, but insightful results. A study in the western Edwards Plateau of Central Texas, where springs were not originally present, found that streamflows did not increase following the removal of Ashe juniper. The authors hypothesized that woody plant removal would augment streamflow only if springs are or have been present naturally. In other words, removing woody plant cover does not "create" springs. The necessary plumbing (i.e., aquifer and associated flow system) needs to be in place in order for precipitation to be received, stored and transmitted to springs.

More recent research by Texas A&M studied runoff generation for a site on the Edwards Plateau following the removal of woody plant cover for a first-order rangeland catchment supplied with intermittent streamflow from a spring at its base. After monitoring streamflow for four years (two before woody plant removal and two following removal), the authors reported, among other results related to runoff/precipitation ratios, that streamflow increased following the removal of Ashe juniper, except during summer months. More precisely, the authors reported that removing approximately 60 percent of the Ashe juniper in the catchment resulted in increased streamflow of approximately 46 mm/year, or 5 percent of annual precipitation, but only for non-summer precipitation events. It is unclear if such increases in streamflow persist following treatment, how variable results are with climate and location, or if these results are applicable on a larger scale.

While the ultimate success of removing Ashe juniper and other woody plants as a means of increasing streamflow is unclear, there are other benefits to removing Ashe juniper in the proper proportion (approximately 60 percent removal). Many of the areas now dominated by Ashe juniper were historic grasslands maintained by buffalo migrations and fire. As buffalo were eradicated and fire has been suppressed, cedar has encroached on much of our native prairies in the Edwards Plateau. Removing Ashe juniper provides the perfect opportunity for reestablishing native prairie grasses to their historic range. This restores the native habitat, but also works to improve the quality of water that recharges into the underlying aquifer as the grasses' extensive root systems aid in filtering the infiltrated water.

One thing is clear, for the state of Texas to be successful in conserving the vital spring resources associated with the Edwards Plateau, we will need the assistance of private landowners whose properties provide much of the recharge that sustains our state's springs. Many private landowners have implemented land management strategies, such as woody plant removal, the reestablishment of native prairies and maintenance of those prairies through prescribed burns and/or rotational grazing, and riparian restoration, that ultimately provide water quality and quantity benefits to us all. Additionally, many landowners are placing conservation easements on their properties to ensure their properties are conserved for future generations, which again ultimately benefits us all in terms of the quality and quantity of water recharging aquifers and running off into creeks, streams and rivers.

Chad Norris is a Natural Resource Specialist with Coastal Fisheries working out of Austin.

REFERENCES

Brune, Gunnar. 1975. *Major and Historical Springs of Texas*. Texas Water Development Board Report No, 189. Austin, Texas. Available online: http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/GWReports/Individual%20Report%20htm%20files/Report%20189.htm

Brune, Gunnar. 1981. *Springs of Texas*. Texas A&M Press. College Station, Texas.

Introducing our new Wildlife Division Director

Clayton Wolf is not a "new face" around the Wildlife Division—he cut his teeth as a wildlife biologist working with private landowners in East Texas, a region of the state that is highly fragmented and at a time when wildlife management was in its infancy. He has served in a variety of roles including Pineywoods district leader, white-tailed deer program leader and big game program leader. Wolf brings with him a strong understanding of the important role the private landowner plays in wildlife management today. Interviewed for the TPWD internal newsletter, Wolf said, "I don't see changes in those things we do best, working with landowners to manage their land best for wildlife."

*[**The Back Porch**, continued from back page]*

and rarely-seen places that tantalize one's sense of adventure and aesthetics. There are thousands of caves in Texas including monsters with miles and miles of passage (the longest, Honey Creek Cave, is over 20 miles in length), caves that are hundreds of feet deep (the deepest, Sorcerer's Cave, is over 500 feet deep), and some that are resplendent with baroque decorations of calcite that rival the most ornate cathedrals in Europe (check out Caverns of Sonora sometime). Where else in Texas but underground can you explore places that no human has ever seen? Most caves in Texas are not long, deep or grand, yet dedicated individuals discover, explore and document them. Cavers discover thousands of feet of new passage in Texas caves each year. As a result, the Texas Speleological Survey maintains a database containing nearly 10,000 caves, sinkholes and springs.

There are many ways that we can protect karst, caves and aquifers. Reducing the scale of development on contributing zones and recharge zones helps ensure that pollution and direct impacts are minimized. Water conservation is an obvious way to reduce urban demands on finite aquifer sources. (Did you know that per capita water use in San Antonio is over 140 gallons per day and that it is even higher in Austin, 177 gal/day?) Minimizing the use of pesticides and yard chemicals helps keep them out of caves, aquifers and your drinking water. Seemingly insignificant actions can have significant effects when many people are involved.

Andy Gluesenkamp is the herpetologist working with the Wildlife Diversity Program out of the Austin headquarters for Texas Parks and Wildlife Department.

Readers interested in learning more about karst, caves, and aquifer issues in Texas may benefit from visiting the following Web sites:

Texas Speleological Survey:
http://www.txspeleologicalsurvey.org

Edwards Aquifer Authority:
http://www.edwardsaquifer.org

National Speleological Society:
http://www.caves.org

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*[**Hidden treasures of the Texas Hill Country**, continued from page 2]*

The interrelationship between karst terrain and groundwater is not difficult to grasp. As surface water travels through karst features such as cave openings, fractures and sinkholes, it carries with it any contaminants it may have picked up along the way, such as herbicides, pesticides and urban runoff. These features have little or no filtration system for traveling water, and over the aquifer's recharge zone, they serve as direct conduits to this underground water supply. This makes for tremendous pollution potential. The Edwards Aquifer and its artesian springs are also home to at least 50 unique aquatic species, including cave-adapted crustaceans, salamanders and two species of catfish. Like their terrestrial counterparts, these are species found nowhere else in the world. Protecting these species and the karst habitats upon which they depend ultimately benefits us as well as them.

Currently, there are 16 karst invertebrates from both the San Antonio and Austin regions that have been listed as endangered by the U.S. Fish and Wildlife Service. Fourteen more species associated with the Edwards Aquifer have been listed as endangered or threatened as well. Efforts are ongoing to monitor and protect these fragile habitats and the rare species that occur within them. For example, biologists from the City of Austin's Wildland Conservation Division and from Travis County's Transportation and Natural Resources Division conduct seasonal biomonitoring inside caves known to contain endangered karst invertebrates. Through their efforts, a better understanding of the population dynamics and habitat requirements of these species may be gained.

Organizations like the Texas Speleological Survey (TSS) and the Texas Cave Management Association (TCMA) are also doing their part to conserve and educate the public on everything karst here in Texas. TSS serves as a storehouse of data on Texas karst for educational, scientific and conservation purposes, while TCMA works with members and partners to acquire and manage caves and karst for protection.

Kathleen O'Connor is a consultant with Zara Environmental LLC out of Austin.

For more information on karst biology and conservation in Texas, visit the following Web sites:

Texas Cave Critters:
http://www.texasento.net/cave.htm

City of Austin:
http://www.ci.austin.tx.us/water/wildland/karstinvertebrates.htm

The Edwards Aquifer Website:
http://www.edwardsaquifer.net/index.html

Texas Speleological Survey:
http://www.utexas.edu/tmm/sponsored_sites/tss/

Texas Cave Management Association:
http://www.tcmacaves.org/index.html

Habitips

Simple things you can do on your land to enhance wildlife value.

April

- Monitor grazing program to provide nesting cover and plant diversity
- Continue controlling feral hogs through hunting or trapping
- Clean and store prescribed burn equipment
- Develop a checklist of birds you see in various habitats
- Clean your hummingbird feeders every three to four days
- Continue to trap brown-headed cowbirds
- Protection of roost sites is essential in areas with limited numbers of large roost trees
- March, April and May are prime wildflower blooming time

May

- Leave some unharvested winter crops next to edges of field
- Monitor grazing program to provide nesting cover and plant diversity
- Prepare ground and plant summer food plots
- Clean your hummingbird feeders every three to four days
- Monitor wildlife food plots. High-protein foods in May and June are critical to good antler growth
- Continue controlling feral hogs through hunting or trapping
- Cowbird trapping season ends May 31. Report all trapping data to TPWD
- After dispersal of wintering flocks, juniper and mid-story hardwoods should be thinned adjacent to roost sites when they become too dense to provide for open space from the ground to tree branches where turkeys roost
- Begin fire ant control as daytime temperatures reach 85 degrees

June

- Monitor grazing program to provide nesting cover and plant diversity
- Continue to control feral hogs through hunting or trapping
- Leave some unharvested winter crops next to edges of field
- Before mowing, walk through hay meadows in order to reduce wildlife mortality, and consider leaving unmowed strips
- Do not mow wildflowers until the seedpods have matured. Mowing at the proper time will ensure reseeding for a good crop for following years
- Make sure summer wildlife water sources are operable
- Clean your hummingbird feeders every three to four days

July

- Monitor/fluctuate water levels in wetland areas
- Monitor grazing program to provide nesting cover and plant diversity
- Continue to control feral hogs through hunting or trapping
- Provide supplemental water for wildlife as necessary
- Complete wetland dike repairs as needed
- Defer grazing in some pastures to ensure adequate nesting cover for ground-nesting birds next spring
- Start planning for fall youth hunts to assist in reaching wildlife management population goals
- Clean your hummingbird feeders every three to four days

Do you enjoy watching hummingbirds in your back yard?

Would you like to learn more about these wonderful birds while helping our biologists learn more about their activities in Texas? Why not join the Hummingbird Roundup?

To join the Hummingbird Roundup, please send a $6 donation with your name, address, city, county, zip, and e-mail address to:
Hummingbird Roundup
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, TX 78744

Hummingbird Wheel

This 10" full-color identification wheel is a helpful reference to keep nearby when you watch the hummingbirds. Sixteen hummingbird species are featured, all of which have been documented in Texas! For each bird, the wheel tells you its range in North America, habitat type, and distinguishing features of both males and females.

Send $11.95 (shipping and handling included) to Texas Hummingbird Roundup, 4200 Smith School Road, Austin, Texas 78744.

TEXAS NATURE TRACKERS

Get Involved

Texas plant and animal diversity is in decline and Texans want to help. Now, Texas Parks and Wildlife Department, along with other partners, offers Texans the opportunity to do just that and you don't have to be a scientist to participate. Through TNT projects, Texans learn how to gather data about various species found on public lands or on their own property. This data is sent to biologists who use the information to give us a better understanding about the trends and management needs of various species in the state.

The aim of Texas Nature Trackers is to ensure that native Texas species will be here for future generations to know and enjoy. To find out more about Texas Nature Trackers, visit: www.tpwd.state.tx.us/tracker/

TEXAS PARKS & WILDLIFE

Texas Parks and Wildlife Department
Wildlife Diversity Program
4200 Smith School Road
Austin, Texas 78744

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KEEP TEXAS *wild!*

The Back Porch

Deep in the Heart of Texas

By Andy Gluesenkamp

Step outside and pick up a rock. The rock in your hand is most likely composed of limestone that was formed when a shallow sea covered much of what is now Texas. Limestone is typical of most karst landscapes, which account for about 20 percent of Texas. A karstic landscape is defined as having been formed by dissolution of bedrock and is generally characterized by sinkholes, caves and springs created by the movement of water underground. Depending on where you live in Texas, the water you drink and the rivers you enjoy may come from a karst aquifer.

In addition to humans, many other organisms depend on karst aquifers for their survival. Dozens of species including crustaceans, fish and salamanders are only found in Texas karst aquifers. The Edwards Aquifer in Central Texas is home to more species than any other aquifer in North America and is the second-most diverse aquifer on Earth. Conservation of this amazing biodiversity becomes a significant issue when one considers that San Antonio is the largest city on the planet that is entirely dependent on aquifer water.

Biodiversity in Texas karst is not limited just to aquatic organisms. Texas has the highest diversity of cave-adapted spiders and beetles in North America, and many of these species are known from only a handful of caves. In fact, over 80 percent of federally-endangered arachnids and the majority of listed beetles in North America are known only from caves in Central Texas. Despite the long history of cave biology in Texas and the relentless pressure of urbanization, new species are being discovered all the time. During the past decade alone, several species of arachnids, insects and salamanders have been discovered within the city limits of some of the region's largest cities. The thought of undiscovered species so close to home certainly played a role in my evolution as a karst biologist. No longer do I have to deal with planning (and paying for) trips to far-off exotic locales to look for new species. I can (and have) simply visit the sinkhole down the street from my house to find bizarre organisms not previously known to science.

In addition to biological treasures, Texas karst contains geologic wonders

[Continued on page 10]