

Saguaro National Park

National Park Service
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Friends of Saguaro National Park



Landscape of Desert Waters
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This book was made possible by the generous support of the Nina Mason Pulliam Charitable Trust and the Friends of Saguaro National Park. We are grateful for their dedication to the protection and study of the natural world and the education of the next generation of park stewards.

If you want to study water, you do not go to the Amazon or to Seattle. You come here, to the driest land. Nowhere else is it drawn to such a point. In the desert, water is unedited, perfect.

*—Craig Childs,
The Secret Knowledge of Water*





Welcome to Saguaro National Park! As one of the more than 400 units of the National Park System, Saguaro protects and manages 91,440 acres of desert and mountain landscapes. The park flanks the east and west sides of the growing southwestern city of Tucson, Arizona. The park was established in 1933, with the specific purpose of protecting and preserving one of the great icons of the American West: the saguaro cactus. In addition, the park offers great biological diversity, rich archeological sites, and thousands of acres of designated wilderness.

Water is crucial to all of the park's ecosystems. In the form of summer rains, water drives the growth of saguaros and brings the desert to life. Flowing underground and in streams, it sustains trees, such as cottonwoods, and animals, such as mountain lions and leopard frogs. It is no less essential for hikers and campers, who depend on being able to find water in springs and tinajas.

This book celebrates water in our park: its movements, forms, and origins, and the way it connects the park and the greater Tucson community. Its purpose is to help all of us understand how vital water is to the park and to Tucson, and to invite visitors to experience these waters that change seasonally and throughout the years. We look forward to working together to help protect the rare, unique, and restorative waters of Saguaro National Park for generations to come.

We are grateful for the support provided by The Nina Mason Pulliam Charitable Trust and the Friends of Saguaro National Park in helping to fund this project, as well as many other scientific and public-outreach projects within the park.

*Leah McGinniss
Superintendent, Saguaro National Park*

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SUMMARY



A waterfall flows below Manning Camp in the Rincon Mountain District.

Background

Saguaro National Park is rare among national parks in that it borders a large metropolitan area. Its two units comprise 142 square miles of wilderness that include both the towering Rincon Mountains to the east of Tucson, Arizona, and the picturesque Tucson Mountains to the west. The park was established in 1933. Through the advocacy of local citizens, it was expanded in the 1960s and 1990s. These strong community ties continue to benefit both the city and the park.

The park's namesake is an iconic desert plant, the saguaro cactus. Water is hard to find here. But where it does occur, it hosts an incredible diversity of life. Moreover, it provides recreation and spiritual nourishment to those who seek it out.

This book celebrates the park's rare waters, describes how they benefit the local community and wilderness, and addresses the threats to their viability for future generations. We explore the many types of water sources in the park and the natural values they provide in the changing ecological, economic, and social landscape of the desert southwest.

Human Use

Because of its scarcity, residents of the Tucson Valley have always been keenly aware of the importance of water. For thousands of years, Native American peoples lived along the floodplains of the Santa Cruz River and its tributaries, gathering riparian plants and cultivating crops in rich soils. Early Spanish and Mexican ranchers and farmers captured the fleeting waters to sustain their livestock, crops, and families—as did the Anglo farmers who followed when Arizona became part of the United States in the mid-1800s. Desert dwellers have always sought out the streams, tinajas, springs, and other sources of water that can mean the difference between life and death.

Today, visitors to Saguaro National Park find solace on the park's winding trails, many of which lead to deep canyons with hidden tinajas, the local name for bedrock pools. These tinajas attract a steady stream of wildlife in the dry months, including frogs, birds, and large mammals. They are also essential sources of water for hikers and backpackers; a portion of the water in the Tucson basin aquifer originates in the park's high country.

Function

Water first enters the park as mountaintop rain and snow. From there, it continues downstream to larger rivers. Below the surface, groundwater flows into the surrounding basins and recharges aquifers, becoming an important source of drinking water for Tucson residents.

Surface water and groundwater are intricately connected. Perennial (year-round) water in the park is closely linked to groundwater sources sustained by precipitation. Riparian trees and other plants depend on shallow groundwater. In turn, these trees support birds and other wildlife.



Hikers look for wildlife at a tinaja.

All of us can help protect Saguaro National Park and the waters within it.

Meeting the challenges to their persistence will require inspiration and collaboration from park staff, park visitors, and Tucson citizens.

Challenges

The quality and quantity of water in Saguaro National Park is impacted by many human activities outside the park. Understanding the nature of these challenges is essential to planning and managing for the future.

Some of these challenges include:

Climate change: Climate models predict less precipitation, longer droughts, and higher temperatures for the Sonoran Desert. These changes will stress plant and animal communities and reduce the amount of water recharging the aquifers. All other threats to park waters will be further exacerbated by a changing climate.

Invasive species: Invasive species, such as buffelgrass, bullfrogs, and fountaingrass, have no boundaries. As they move into the park from adjacent properties, some of these species are changing the fire regime, outcompeting native plants and wildlife, decreasing biodiversity, and severely impacting watershed health.

Wildfire: Natural fires are important to maintaining healthy forests, but decades of fire suppression have led to some very large fires that can alter soil structure and create erosion. After a fire, sediment is carried into streams and pools, making them unusable as wildlife habitat for many years. In addition, desert fires fueled by invasive plants kill native species, such as saguaros, that are not fire-adapted.

Groundwater pumping: Groundwater pumping lowers the level of the water table and changes how water moves between the sub-surface and the surface. Excessive pumping can lower groundwater levels below the depth needed to sustain vegetation. If levels drop too low, then the flow of water to springs, tinajas, and creeks may cease altogether.



Action

Protecting these amazing but vulnerable waters is a group effort. For the community that depends on water from Saguaro National Park, the land managers and policymakers who manage it, and the individuals who seek its ecological and recreational values, this book is a call to action to work together to protect and restore the park's natural desert waters.

*Action can be taken at all levels—
from public officials to groups,
neighborhoods, and individuals.*

Possible actions include:

Education: Change begins with information. The park provides many education-based opportunities and Tucson is known for its impressive water education and conservation programs. Through education, we can help inspire the community to preserve and protect our water, our wilderness, and the resources they provide.

Water conservation at home: Because groundwater runs from the park into the surrounding basins, reducing water use in homes can help protect the water in Saguaro National Park. Simply taking shorter showers or opting for a low-water, xeriscaped yard can save surprising amounts of water.

Support and visit the park: One of the most important ways to understand and protect the park is by visiting and supporting it. Anyone can become a citizen scientist, volunteer on a buffelgrass pull, or join the Friends of Saguaro National Park. Most importantly, people who care about the park can visit often and bring their friends and families. This is especially true of young people, who will become the next generation of park stewards.



A saguaro cactus stands tall against the sunset at Saguaro National Park.

CHAPTER 1

INTRODUCTION

Saguaro National Park

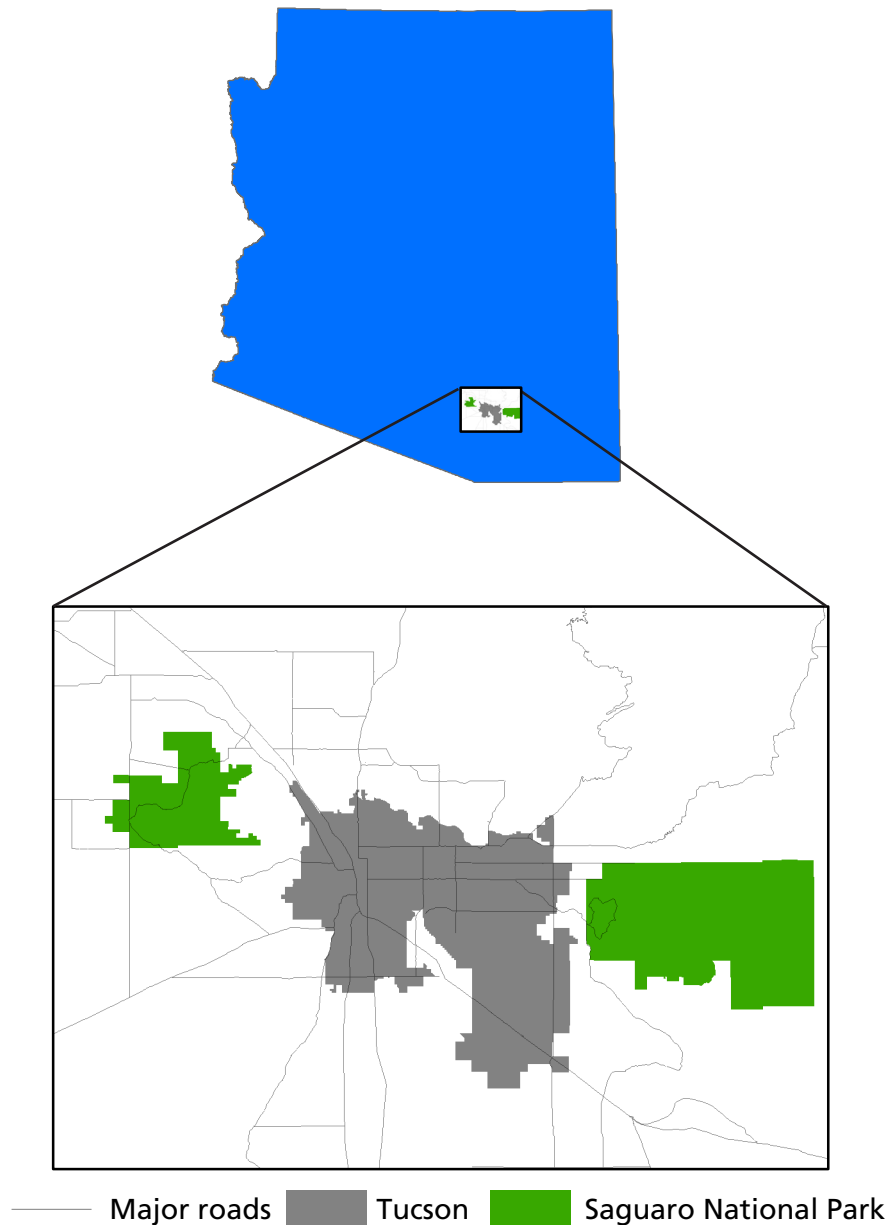
Saguaro National Park is located in southeastern Arizona. Its two units bracket the desert city of Tucson, a community of nearly one million people. As one of the oldest continually occupied places in North America, Tucson is a city of incredible cultural, biological, and topographic diversity. It sits in a valley nestled between tall mountain ranges, where majestic saguaro cacti give way to towering pine forests.

The park's east district was first preserved as a national monument in 1933. Local residents saw the unique value of the saguaro Cactus Forest and the mountains beyond it and lobbied strongly for federal protection of the land. As Tucson grew and the cactus forests shrank, the west district, in the Tucson Mountains, was added to provide additional protection to the saguaros and Sonoran Desert ecosystem.

In 1994, Congress designated the area as a national park. Today, 91,440 acres of land are protected in the east and west districts of the park. Over 78% of that land is preserved and managed as wilderness.

The park's two districts are undergoing rapid change as more people move to the city and surrounding areas, pushing development to the boundaries of the park. Park resources are increasingly challenged by invasive species, noise and light pollution, and other impacts of urban development.

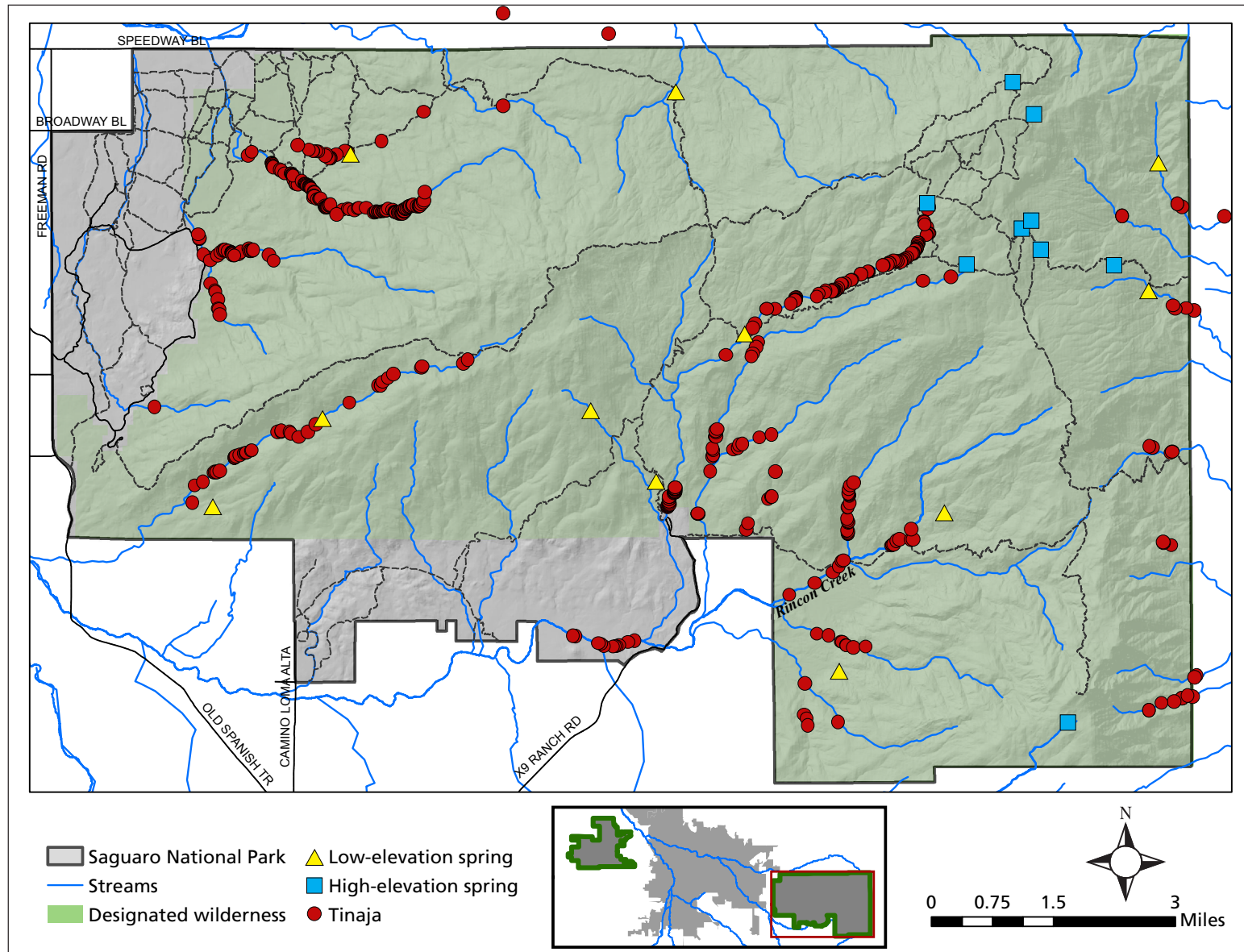
Despite being a desert park, Saguaro National Park is defined by water. The park's naturally occurring surface waters sustain plants, animals, and people during the driest times of the year. Water is essential both for the health and well-being of Saguaro's wilderness and for the future of Tucson and its inhabitants.



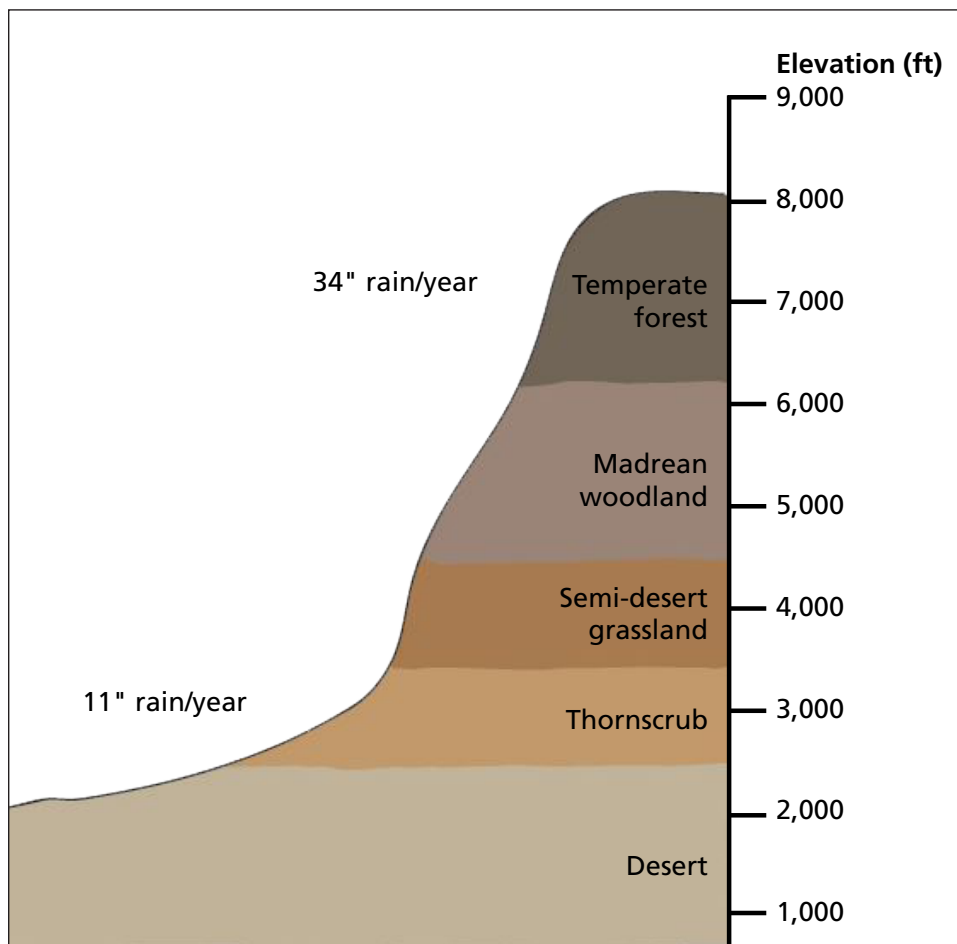
Where is the Water?

The high peaks of the Rincon Mountain District receive rain and snow that flows down the mountains, providing water for streams, tinajas, and springs. Because there is no naturally occurring perennial water in the Tuc-

son Mountain District, this report focuses primarily on water sources in the Rincon Mountain District.



Low-elevation springs, high-elevation springs, and tinajas of the Rincon Mountain District, Saguaro National Park.



Life zones and average precipitation of Saguaro National Park's Rincon Mountain District.

The Water Year

Water in the park is ever-changing. Most of the time it is well-hidden, but during and after heavy storms, it can seem that even the smallest rivulet and puddle are flowing and full. Surface water is captured in a variety of wetlands that change with the season and from year to year, such as springs, seeps, tinajas, streams, washes, and ponds.

Arizona experiences a generally bi-modal pattern of precipitation that shapes the landscape of water in Saguaro National Park. Much of the park's water falls as rain and snow in the winter months of November through March, the result of slow-moving storms that move east off the Pacific Ocean. This winter moisture recharges springs and streams throughout the springtime.

The driest time of year in the park is typically June and early July, as temperatures rise to more than 100 degrees F. July, August, and early September bring the summer monsoon rains. These are often violent, localized storms that can drop large amounts of rain in a short burst. The fall months are usually dry, but every few years the park receives heavy rains from strong Pacific Ocean storms that work their way north along the southern Pacific coast.

On average, desert areas of the Tucson Mountains receive about 11 inches of rain per year. High elevations in the Rincons receive even more rain, with approximately 34 inches falling at Manning Camp, at 8,000 feet.



Desert streams flow with runoff as mountain snows melt.

CHAPTER 2

EXPLORING PARK WATERS



Mountain snowmelt fills Rincon Creek with water.

Springs

Springs are rare in the desert southwest. They are special micro-habitats, offering a wet environment for species that would otherwise not be able to live in the desert. Although they account for less than one percent of the land in the southwest, springs have some of the greatest biodiversity in the region. Dozens of plant species grow in the moist soil and channels around the springs in Saguaro National Park, especially in the Rincon Mountains.

Springs sometimes go unnoticed, hidden as thin veneers of water flowing over slabs of bedrock or small areas of green, lush ground. But in the far backcountry of Saguaro National Park, the springs that burble to the surface are hotspots for plants, animals, and hikers.

Under the towering pines and aspens of the high country, wild turkeys splash in the shallow water of these springs. Deer quietly pad across the moist ground, browsing on the lush, green plants, always alert for predators. Even animals that roam large areas of wilderness, such as mountain lions and bears, converge at the springs to quench their thirst.

These animals share the springs with human visitors. As the primary source of water for backcountry explorers in the Rincons, springs are essential to recreation in the park. They are a place of solace and peace after long, dusty hikes up the mountain, quenching the thirst of parched visitors. There are no roads into the backcountry, so hikers must carry all their water with them or have reliable places to refill their containers. Without springs, long trips into the wilderness would be next to impossible. There are few other perennial water sources at high elevations.



Italian Spring, Rincon Mountains.



Springs have a long history in Saguaro National Park. Spud Rock Spring was originally used by nearby inhabitants who farmed potatoes. The spring was once highly developed, with a cement spring box, lid, and pipe leading to a large storage tank. Today, it stands alone on the edge of a meadow, with only some rocks remaining from the original built structure. *Left: Spud Rock Spring, 1951. Right: Spud Rock Spring, 2010.*

Historically, the springs in the Rincon Mountains were heavily used. Ranchers in the late 19th and early 20th centuries depended on them as a source of water for their cattle. Many were dug out and reinforced with rocks, channeled into cement troughs, or piped into storage tanks to increase flow and store water for dry times. Jelks Spring, on the south side of the Rincons, is one example. Rukin Jelks owned 3,000 acres of ranch land to the south of the park and ran cattle in the park in the 1930s. He developed a cement spring box and one-inch steel pipe to move a purported 8,000 gallons per day over two miles to his ranch in the valley below.

Like Jelks Spring, Spud Rock, Deer Head, Mud Hole, Mint, Italian, and other springs all flowed in the past and were developed for human use. Jelks Spring is now often dry. There is evidence that several others are also going dry much more frequently than in the past. Deer Head Spring used

to be one of the most reliable springs in the Rincon Mountains (accounts of it go back to the 1920s), but for the last 10 years it has been mostly dry or only muddy. Water availability at Spud Rock and Mint springs also seems to be less reliable than in the past.

It is possible that past human use and maintenance of springs kept their water at the surface, whereas today, the water is more available for the roots of plants. However, springs are particularly vulnerable to disturbance. Trails, human visitation, grazing, fire, and floods can all damage springs by degrading the water quality, decreasing or stopping the flow, or damaging or diminishing soils. Because springs are so important as ecological refuges, backcountry water sources, and places of spiritual nourishment, Saguaro National Park is engaged in learning more about their dynamics and exploring management options to best protect them.



NPS/DREW JACKSON

Gushing water at Saguaro National Park.



Adopt a Spring

Until recently, Rock Spring flowed into a large tank. In 2009, the pipes that fed water into the tank were disconnected and the tank was allowed to drain. Although some people still mourn the non-native goldfish that once inhabited the tank, others find hope in the recovering landscape. The spring has largely returned to its natural state, with renewed plant growth, increased flow, and even the occasional presence of lowland leopard frogs. Volunteers from a local non-profit, the Sky Island Alliance, have adopted Rock Spring and now regularly monitor the wildlife, plant life, and water found there. Rock Spring is a heartening example of the resiliency of desert springs.



Volunteer Spotlight

Long-time Saguaro National Park volunteer Chuck Perger is the unofficial expert of Rincon Creek. Every two weeks for the last 14 years, Chuck has walked the length of the creek as it runs through the park. During these visits, he looks for reaches that are wet or dry, checks water levels, installs monitoring instruments, and looks for his favorite residents—two beautiful owls. Because of Chuck's dedicated work, the park was able to gather data to support an application for a water right on the middle reach of Rincon Creek. The claim would protect a certain amount of water in the creek to preserve the ecosystems that depend on it. The water rights adjudication has not yet been resolved.

Streams

As streams carry rainwater, melting snow, and sediment from the mountains to the desert, they create the rugged landscape of Saguaro National Park. Most of the park's streams begin in the mountains, carving canyons into the rock. From there they drop more gradually into the desert basins below, depositing sand and gravel along the way.

Streams provide many upstream and downstream benefits. They play an essential role in the quality and supply of Tucson's drinking water by recharging underground aquifers and surface water features. Headwaters, seasonal streams, and rain-dependent streams all store water. When they are healthy, they protect downstream communities by moderating flooding and maintaining flow during dry weather.

As groundwater moves into streams, it moistens soils, irrigates vegetation, and carries nutrients essential to plants and animals. Surface water can seep into the ground through the stream bed and then resurface and replenish flow further downstream. Park staff have seen Rincon Creek go from dry to flowing even in the absence of rain, as water from rain events days or weeks earlier slowly worked down the mountain through groundwater pathways.



Grassland stream rages with water.

This interplay between surface and groundwater in streams helps sustain riparian areas even during the driest months. Riparian areas are wetlands adjacent to rivers or streams. They contain trees and other plants used by desert wildlife. Although riparian habitat comprises only 0.4 percent of Arizona's total area, it provides some of the most productive and valuable natural resources in the state, supporting thousands of plants and animals.

The middle reach of Rincon Creek, which forms the southern boundary of the east district, contains the largest and most developed riparian woodland in Saguaro National Park. The shallow groundwater keeps the roots of cottonwood, sycamore and walnut trees wet, allowing them to survive and grow tall. Frogs and turtles depend on these waters, as do many other land-dwellers that must drink to replenish water loss. In addition, the creek's surface water attracts insects and other invertebrates that are eaten by larger animals. Riparian woodlands also provide important seasonal feeding areas, refuge from predators and competitors, shelter from extreme weather, and travel corridors for many kinds of wildlife.



Black phoebe.

Riparian Habitat and Landbirds

Riparian woodlands support many birds native to the desert southwest. In fact, more than half of southwestern birds depend on riparian vegetation. Birds use these water sources for breeding, nesting, and rearing young. Some birds forage for food in wetland soils. Others feed in the water column or glean insects from the leaves of tall trees.

Recent research has shown that streams and riparian woodlands may also be crucial molting areas for some migratory species. During molting, a bird sheds old, worn feathers to replace them with fresh plumage. This process requires lots of energy, and can cause birds to become stressed. Riparian areas, rich in nutrients and resources, help the birds to replenish themselves.

A number of birds that use Rincon Creek have special conservation status in the U.S. The grey hawk (*Buteo niti-dus*), which nests in the middle reach, and the peregrine falcon (*Falco peregrinus*), which also uses the area, are both listed as Species of Concern by the U.S. Fish and Wildlife Service. The yellow-billed cuckoo (*Coccyzus americanus*), also found in the middle reach of Rincon Creek, was recently listed as a Threatened Species.



Rincon Creek flows after a rainstorm.



Sonoran mud turtles are sensitive aquatic species that live in permanent water sources. During the winter or periods of long drought, they may move underground to wait for better conditions before re-emerging.



A lowland leopard frog basks in the sun.



Blackneck garter snakes hunt frogs and toads at tinajas.



Black bears use tinajas as water sources and to cool off.

Tinajas

Tinajas are one of the most important water sources for wildlife in the park. These pools, which form in bedrock, are scoured out by flowing water. Tinajas are often the only source of available water during the driest seasons of the year. Several of them hold water even during the longest periods of drought. The park has records of more than 240 tinajas, though many more exist. These small oases are scattered across more than 100 square miles, accounting for only a tiny amount of land in the wilderness.

Given the limited amount of water they hold, tinajas are disproportionately important to the ecosystem. Wildlife depend on them in all seasons. In the summer, mountain lions and javelina avoid the blistering daytime heat by visiting the pools at night. Bats swoop low over their surfaces to drink and also feed on insects attracted to these waters. During the day, blackneck garter snakes wind through the water, looking for prey—then sun themselves on the hot rocks.

Other animals, like the Sonoran Desert mud turtle and lowland leopard frog, live their entire lives in or around the pools, finding refuge from predators under rocks and searching out meals in the shallows. The lowland leopard frog, once found throughout the Tucson basin, is now limited to tinajas in and around the Rincon Mountain District of Saguaro National Park. Park researchers trek through long, steep canyons each fall and spring to monitor these frog populations.



Tinajas fill with water and come to life as snowmelt makes its way down the Rincon Mountains.



Dennis Caldwell releases fish into a backyard pond.

Park Neighbors Rescue the Lowland Leopard Frog

The lowland leopard frog (*Lithobates yavapaiensis*) is struggling to survive. Because these frogs must stay wet, they live in pools that contain water year-round. However, their habitats are disappearing—and so are the frogs.

To help save the lowland leopard frog, neighbors from Tucson's "Notch Neighborhood" worked with biologists from the park, the Arizona Game and Fish Department, and other organizations to form the Neighborhood Backyard Pond Project in 2004. This project helps park neighbors and volunteers to improve the frogs' chances of survival by creating backyard habitats to rear and raise the frogs.

Pond owners purchased equipment for the ponds, including lines, skimmers, pumps, and filters. Saguaro National Park then provided the frogs and advice. The Rincon Institute paid for technical support and monitoring by independent biologist Dennis Caldwell.

The Notch Neighborhood lies on the northwest side of the Rincon Mountain District, within the Pima County designated buffer zone. This zone provides a buffer zone for wildlife between the security of the park and the major urban landscape of the city. "As a neighborhood, we are trying to be a viable extension of the open spaces in the park, which means we are concerned about water, we are concerned about vegetation, we are concerned about all the things of the park," said Karen Reifschneider, a 15-year resident of the neighborhood.

In summer 2005, park staff selected partial egg masses and a number of tadpoles from water sources in the park. They were brought to ponds created in the Notch Neighborhood. Most of the tadpoles ended up only a few miles from their original pools.

This project hasn't been easy. American bullfrogs, which are exotic to this region of the U.S., are the main threat to its success. "If you have bullfrogs in a water source, you just don't have anything else," Reifschneider said. The leopard frogs are also affected by the chytrid

fungus carried by the bullfrogs, which come from nearby water features and yards. “Even though I was getting the bullfrogs out of the ponds as fast as I could, they were leaving the disease behind,” said Caldwell. To solve the bullfrog problem, Reifschneider had to fence her pond.

Reifschneider tends to look for the silver lining in these issues. “We have had a lot of setbacks . . . but I think [they] are useful because we learned things we didn’t know before,” she said. “That has been the weird part about this whole thing,” he said, “It hasn’t been the successes but more the failures that have been the most eye-opening and valuable part of this project.”

Today, biologists continue to monitor frog populations. Plans are being made to move frogs from the backyard ponds back into areas where lowland leopard frogs once occurred in the park.

There are not enough resources available to expand the backyard pond program at this time. However, there are many things people can do to promote success of already-existing ponds.

- Learn to identify bullfrogs and remove them from your own backyard water features. Do not release them back into washes or other environments.
- Put bullfrog-proof fences around backyard ponds so bullfrogs cannot reach the water and use it as an avenue to access lowland leopard frog ponds in your area.
- Try to avoid introducing non-native species, such as goldfish, bullfrogs, and non-native fish and turtle species to backyard ponds. They have the potential to escape, become invasive, and spread disease.
- Do NOT release any animals (e.g., fish, amphibians, reptiles) into washes and streams, even if you think they are native species. It is easy to misidentify species and introduce a non-native.



American bullfrog.

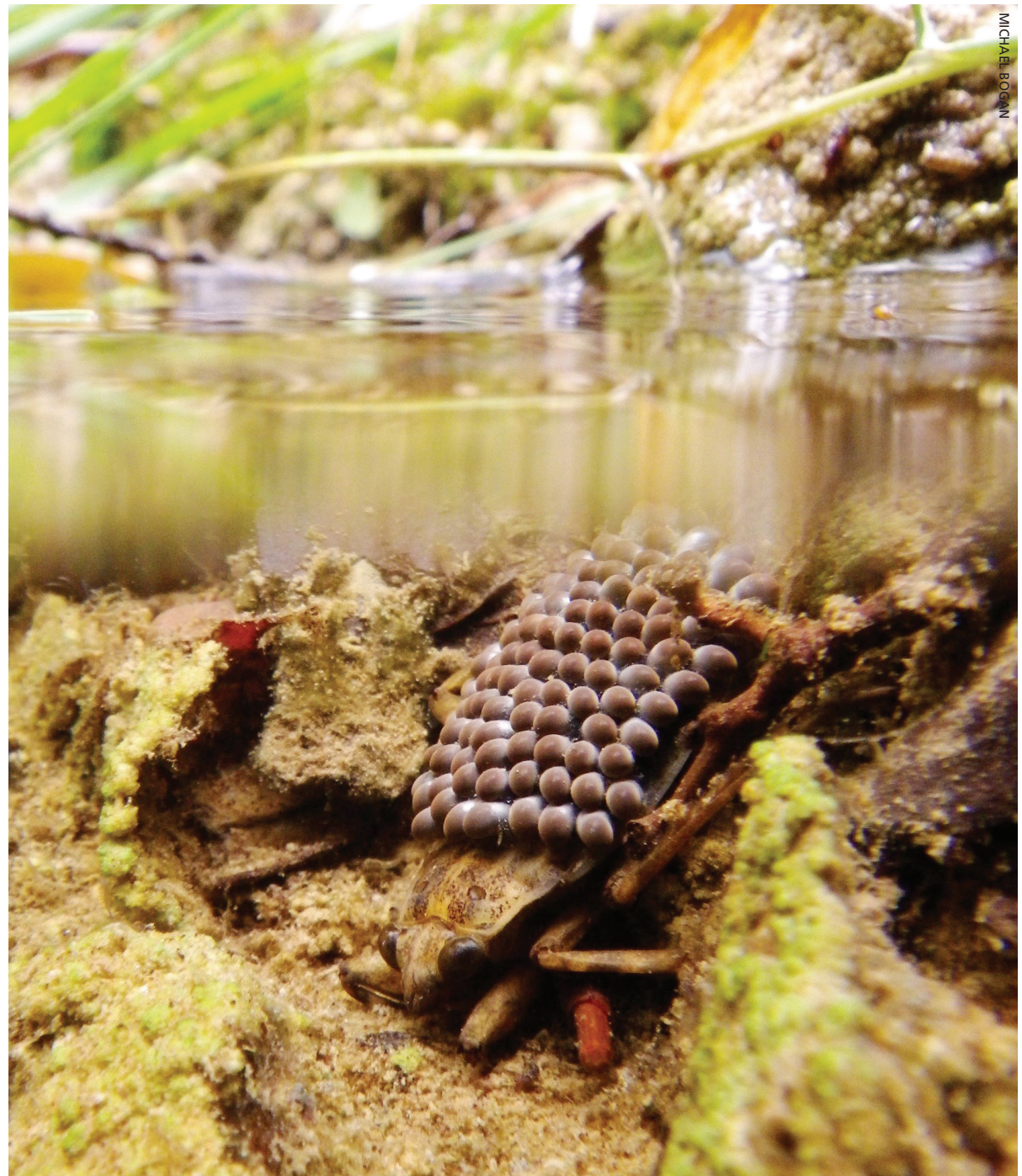
Giant Water Bug

Lying motionless at the bottom of a tinaja, clinging to a plant stalk, a giant, oval insect spots a mud turtle. It pounces. Swimming in streams, tinajas, and springs within Saguaro National Park, giant water bugs (*Abedus herberti*) fill a crucial biological niche.

Giant water bugs are fierce predators. Their menu ranges from aquatic insects to frogs, mud turtles, and garter snakes—these bugs can eat animals up to 50 times their size. The males show a rare example of paternal care in insects. They carry 30–100 eggs on their backs for 1–3 weeks until they hatch, ensuring the eggs don't drown or dry out.

These bugs also have impressive flood-escape behaviors. Listening for monsoon rainfall as a cue, they will slowly crawl out of the water before forceful rains wash them away.

Ecologist and researcher Michael Bogan studied these insects at the park and found that increasing drought is causing giant water bugs to vanish. During the summer, water sources typically dry up, leaving just a small collection of shallow pools where the bugs are able to survive. Bogan found that when the pools went completely dry, many of the bugs disappeared. Even when rains brought rushing water back through streams, the water bugs didn't return. The disappearance of the giant water bug from many areas of the park provides evidence that even insects are being affected by drought and a changing climate.



Male giant water bugs carry eggs on their backs until they hatch.



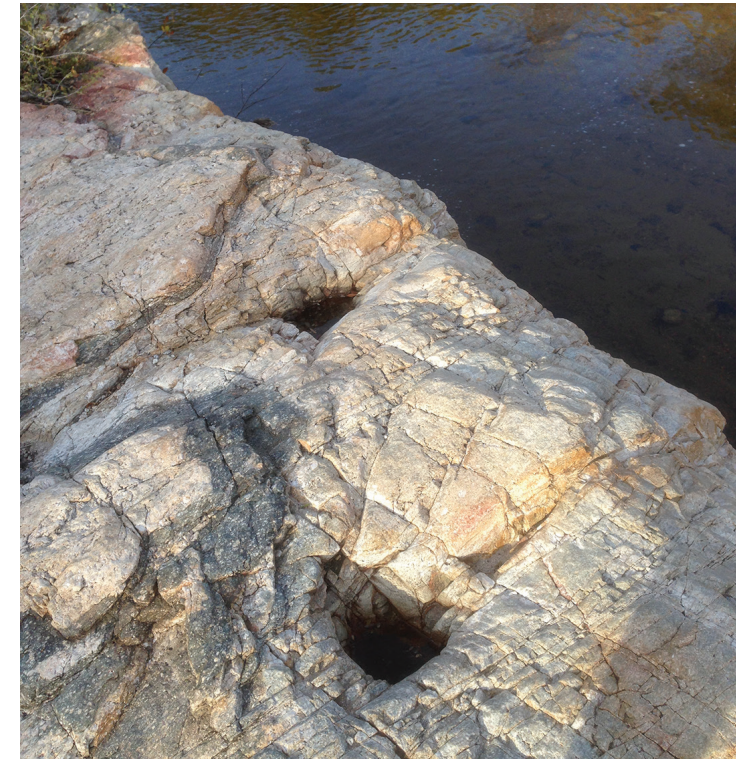
Diatoms (small, unicelled algae) are found in the warm, sunny waters of tinajas. These small organisms can only be seen with a microscope but play an essential role in the ecosystem.

Under the surface of tinajas lives a vibrant community. Tadpoles and insects bask in the shallow waters, flit across the surface of pools, and lurk along the bottom. Placed under a microscope, even a single drop of tinaja water becomes a writhing puddle of life, populated by diatoms. These unicellular aquatic microorganisms are one of the largest and most ecologically significant groups of organisms on Earth, providing a quarter of all photosynthesis for the planet. Without the oxygen they bubble into the atmosphere, we would all be left gasping for air.

Diatoms are also valuable ecological indicators of environmental changes. By analyzing sediment cores from lakes, scientists can see patterns of change in dominant species of diatoms because the transparent walls that make up their structure do not degrade. These unique microorganisms are currently thriving in park waters.

Humans also use the park's tinajas, and have been doing so for many generations. Deep, round pockets can sometimes be found carved into flat, exposed slabs near the pools. These mortars were formed as the Hohokam people ground mesquite pods into meal. Bedrock mortars exist across the United States, but in Saguaro National Park they are most commonly found near tinajas—evidence that these pools have been attracting humans for centuries.

Still, tinajas are one of the park's most mysterious water features. Many remain



Bedrock mortars are the precontact equivalent of today's food processors. These anthropogenic, circular depressions in rock outcrops or naturally occurring slabs were created as people ground grain, acorns, and other foods. They are often found in clusters near perennial pools.

wet all year, even after the streams have stopped flowing and the rains have ceased to fall. Scientists think these pools are sustained by groundwater—water that has percolated into the ground and seeps through soils and rock fractures before entering the pool. The dynamics of tinajas are difficult to study because the pools are often located in remote canyons, where groundwater enters through discrete cracks beneath the surface.

There has been an increased effort in the last several years to study the origins of the groundwater in these pools to better understand and protect these critical waters.



A dry, rocky wash in Wildhorse Canyon.

Washes

Washes are stream channels that are dry most of the year. During the summer monsoon, though, they can quickly turn into torrents of churning water.

The anticipation of the summer rains builds through the hot, dry months of May and June as clouds grow, melt, and float away. In early July, storms creep along the horizon, growling with thunder, flashes of dry lightning, and the tantalizing smell of desert rains. Finally, dark clouds obscure the sun, the winds start blowing, and the long-awaited waters cascade from the sky.

“The violence of the real storms, when they finally do hit, never ceases to astonish and even frighten me,” writer and scientist Janice Emily Bowers wrote in her collection of essays about the Rincon Mountains. The rain falls so quickly that the ground doesn’t have a chance to soak it up, so it comes crashing through washes in a muddy torrent.

The life of these raging waters is short, often lasting only a few hours, but during that time they can cause extreme destruction. Flash floods can reshape washes in just one event, ripping out trees, cutting deep channels, and washing away cars and even buildings.



Washes are prone to flash floods of incredible force that sweep through drainages when the rain falls heavily for a short period of time. This wildlife camera caught a flood that passed through a small drainage in a matter of hours.

After a monsoon storm, the desert comes to life. Saguaro cacti soak up even the barest hints of water with their shallow, widespread roots. Wildflowers spring from wet dirt. Dormant moss greens up to photosynthesize. Each drop of moisture is jealously guarded with spines, teeth, and efficient water use.

Spadefoot toads, cued by the low vibration of rainfall on the ground, pull themselves from the soil where they have waited since last monsoon season to quickly mate before disappearing below the ground again. Their eggs, laid in temporary pools, take advantage of the short-lived surface water by hatching just 15 hours later.

Even when the washes are dry, they are vibrant with life. Wildlife use the open, sandy corridors to avoid spiny cactus and acacia plants and travel quickly across the land. National Park Service employees have placed wildlife cameras along the washes to help record the animals living in the park. These cameras have captured images of mountain lions, bobcats, quail, skunks, deer, javelina, and many others using the washes.



In the 1930s, the Civilian Conservation Corps (CCC) tried to harness the power of the water in the washes. CCC crews built many dams across washes to prevent erosion and attract wildlife to trapped waters. Many can still be seen in Saguaro National Park, especially in the Tucson Mountain District. Although most have filled with sediment or fallen into disrepair, their remnants stand as a reminder of the strength and resiliency of our country during its most trying times. This CCC dam still stands in the Tucson Mountain District.

Wildlife Watering Facilities

There are four watering facilities in the Tucson Mountain District. Two were built by the Civilian Conservation Corps. The Dobe Robinson and Red Hills facilities, completed in 1937, provided supplementary water for wildlife and shallow water habitats for amphibians and reptiles. Both facilities have a windmill and well box for holding water and pumping it to a concrete-lined pond. In 1990, these facilities were upgraded as part of mitigation for the Central Arizona Project. However, due to lack of maintenance and dam breaches, both are dry today. The Dobe Robinson facility is shown here.

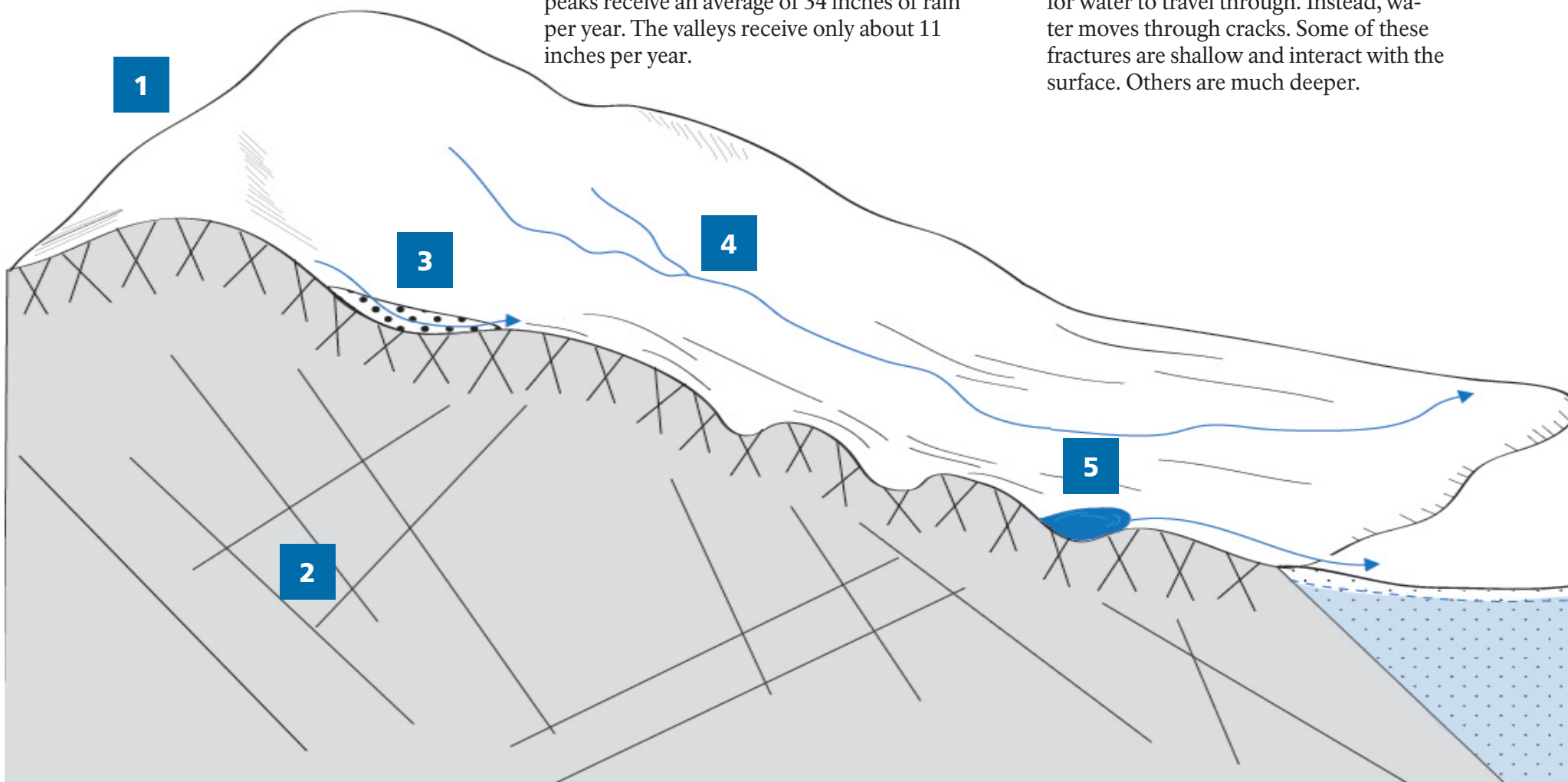
CHAPTER 3

THE ORIGINS OF PARK WATERS

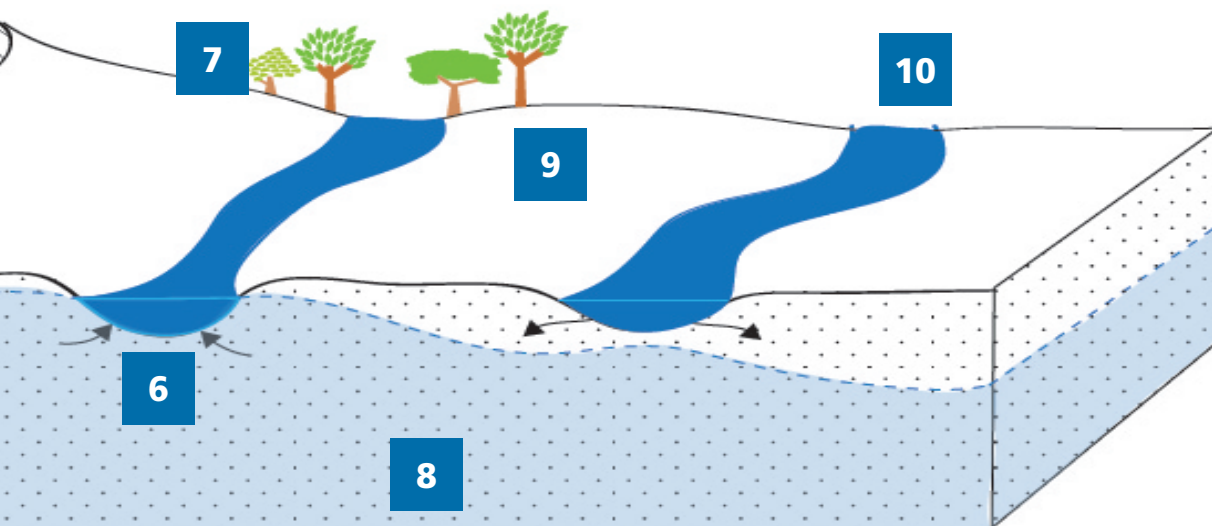
From the moment it falls on the mountain peaks until it spills into the valley below, water is connected across the landscape of Saguaro National Park.

1 Water first enters the park as either rain or snow. Cold air can hold less moisture than warm air, so more precipitation falls on the mountains than in the valleys. The Rincon peaks receive an average of 34 inches of rain per year. The valleys receive only about 11 inches per year.

2 The Rincon Mountains are huge domes of crystalline bedrock that were moved to the surface from deep within the earth millions of years ago. There are no pores in the rock for water to travel through. Instead, water moves through cracks. Some of these fractures are shallow and interact with the surface. Others are much deeper.



- 3** At springs, groundwater is exposed to the surface. In the Rincon Mountains, many springs arise from small, shallow basins filled with broken rocks and soil. When it rains or snows, water travels through the sediment. When it reaches bedrock, the water is forced to the surface as a spring. Other springs occur where water-filled fractures meet the surface and water overflows onto the land.
- 4** Precipitation that doesn't infiltrate into the ground or evaporate runs down the mountain faces in drainages.
- 5** Tinajas, found in drainages, are a unique combination of surface water and groundwater. Not all tinajas have a groundwater contribution, but if fractures intersecting the pool contain water, the pool can fill. When the drainages are flowing, all the tinajas are filled with water.
- 6** The water table is the level at which water surfaces in an aquifer. In an unconfined aquifer, water flows from places where the water table is high to places where the water table is low.
- 7** The last two substantial riparian areas in Saguaro National Park are along Tanque Verde and Rincon creeks. Although there isn't always surface water present in these creeks, the groundwater is close to the surface. Trees like cottonwoods, willows, and mesquites tap into the shallow groundwater.
- 8** The large, deep Tucson Basin is filled with thick layers of porous rock. The sediment of the basin holds water like a sponge. The pores between the sediments are connected, allowing water to flow within them.
- 9** When the water table is high enough to intersect with the streambed, groundwater enters the stream. These portions of the stream are called gaining reaches. Streams with gaining reaches can be perennial or intermittent.
- 10** When the water table does not intersect with the streambed, water seeps out of the stream and into the ground. This is called a losing stream. Washes are good examples of losing streams. Their sandy bottoms easily let water move downward until it reaches the aquifer.





Snowfall in the high country. (NPS/Christopher Morris)

Snow

The peaks of the Rincon Mountains typically receive at least three times more precipitation than the Tucson Basin, below. Much of this precipitation occurs in winter. In some years, beautiful blankets of snow cover the peaks. In the much warmer valleys, slow-moving winter storms drop gentle rain.

Snow plays an important role in the ecosystem. Unlike rain, which runs off quickly, snowpack stays on the mountains. During the spring it slowly melts, allowing water to seep into the ground and feed springs and streams.

Snow is one of the resources most immediately threatened by climate change. Because of rising temperatures, storms that once brought snow to the mountains may drop rain, instead, changing the dynamics of water across the landscape.

Isotopes

Isotopes are different types of the same atom. Their nuclei contain equal numbers of protons but different numbers of neutrons, so they differ in atomic mass but share the same chemical makeup. Heavy isotopes behave differently than light isotopes. The ratio of heavy to light isotopes in water can tell us about the journey the water has taken. The isotopic signature (that is, which and how many isotopes are present) tells scientists how old the water is, whether it fell as rain or snow, and if it fell in summer or in winter.



Y. JINGHONG

Tracking the Age and Origin of Park Waters

Chris Eastoe is a retired isotope geochemist. During his career with the University of Arizona's geosciences department, one of the things Eastoe focused on was water. "I began my interest in isotope hydrology by looking at the Tucson Basin," said Eastoe. "I worked on drawing together a unified vision of how isotopes help us understand the plumbing of the basin." Using multiple techniques, Eastoe was able to figure out how old the water was, whether it first fell as rain or snow, and where recharge was occurring. He could also map the paths of water as it moved through the Tucson Basin. At Saguaro National Park, Eastoe measured isotopes in springs at both low and high elevations. The results showed that the high-elevation springs, previously thought to be fed primarily from snowmelt, are actually a mix of summer rain and winter snowmelt. The results also showed a range in the age of the water in the park. Although most of it was recent, some of the samples tested included water that was recharged before the 1950s.



Water flows from Loma Verde Wash, in the Rincon Mountains, toward the Tucson Basin.

Beyond The Park

Water knows no political boundaries. On the surface, water flows down streams, across park and forest boundaries, and into basins outside these areas. From there, it continues downstream to larger rivers or into aquifers. Below the surface, groundwater flows into the surrounding basins and recharges aquifers, becoming an important source of drinking water for Tucson residents.

The watershed that begins with Saguaro National Park also provides many ecological services for local communities. Water that originates in the park is free from the agricultural runoff, urban pollution, and toxic chemicals that sometimes occur in developed watersheds. The park's riparian areas slow flood waters and provide wildlife habitat. Finally, the park's biodiversity makes the watershed more resilient to natural stresses, such as drought and fire, improving water quality and quantity.



Water makes its way from Saguaro National Park to the Rillito River in the Tucson Valley.



Backcountry tinaja.

Water and Wilderness

In 1964, President Lyndon B. Johnson signed the Wilderness Act into law. This law created a formal mechanism for designating wilderness and mandated its protection. Today, more than 100 million acres of federal public lands are wilderness. Forty-four million of these acres are in 47 national parks. Wilderness makes up 53 percent of National Park System lands.

The Act defines wilderness as

an area of undeveloped Federal land retaining its primeval character . . . without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions. . . . [and provides] outstanding opportunities for solitude or a primitive . . . type of recreation . . .

Because of these protections, wilderness areas throughout the country and within Saguaro National Park preserve watersheds that provide clean drinking water to millions of people in cities and rural communities. When wilderness is threatened, so is its ability to provide these services.

Nearly 80 percent of Saguaro National Park's 91,440 acres are federally designated wilderness. The Saguaro Wilderness protects a prime Sonoran Desert ecosystem, showcasing majestic saguaro cacti, wildlife habitats, critical riparian areas, and high-elevation ecosystems. It also protects cultural sites important to the Tohono O'odham people.

This protection provides Tucson residents the opportunity to enjoy the many wonders of the Sonoran Desert right in their city's own backyard. Although the wilderness protects many of Saguaro National Park's water sources, surface water is scarce during most of the year.

If you do venture into the Saguaro Wilderness, start your trip with plenty of potable water. Know where water sources are located. Ask park staff about current water conditions, and plan your trip according to water availability.

“Any development in the history of the Tucson community has been and will continue to be dependent on water sources and the rate of that development is dependent on water access. I think telling the story of water is essential to understanding our history.”

—Robin Pinto,
Tucson historian

CHAPTER 4

A VULNERABLE PARK



Tinajas drying up in Rincon Creek.

All aspects of the Saguaro National Park ecosystem are connected. Changing one aspect of the system can affect all the other parts, which cannot be considered as separate from the whole. In this sense, the threats to the park's water resources are many. They are both local and far-ranging.

Wildfire

Wildfire can be both beneficial and destructive to the park's environment. In mountain habitats, woodlands and forests are adapted to low-intensity fires that historically occurred every five to ten years. These patchy fires thin out existing stands and encourage a mix of young and old trees. They also protect trees from blights and recycle nutrients into the soil.

Over the last several decades, land managers have begun to appreciate the value of fire to western pine forests. However, many years of fire suppression have led to fuel buildup and unnaturally thick forests. These conditions increase the risk of high-intensity fires that kill most of the trees in their paths and scorch the soil, making regeneration difficult.

In desert habitats, fire is rare. The wide spaces between plants make it difficult for fire to spread. When invasive plants, such as buffelgrass, fill in the spaces between native plants, fire danger increases exponentially. Desert fires can harm habitat and kill saguaros and other natives not adapted to fire.

Whether in the forest or the desert, high-intensity fires affect the quantity and quality of water in streams. Polluted air causes trees to accumulate heavy metals, such as aluminum and lead. If too many large trees die in a fire event, there may be pulses of heavy metals in stream water.

A more immediate problem is the dramatic effect of fire on watersheds. After a fire, runoff increases in burn areas. Instead of being trapped by plants and infiltrating into the soil, water flows over the bare ground, picking up sediment. Streamflow increases substantially, especially during heavy rain events. Erosion also increases. Downstream reservoirs may fill with sediment and debris, eliminating habitat. Recovery can take decades.



After large wildfires, tinajas often fill with sand. These photos show Pool 1 in Loma Verde before and after the 1999 Box Canyon Fire. It can take years for the sediment to flush from the pools. During that time, populations of species that depend on the pools, like lowland leopard frogs, can die off in those drainages.

Invasive Species

In the Sonoran Desert, many non-native and invasive species threaten water sources and the species that depend on them. Two of the most potentially destructive invasive species are the American bullfrog and buffelgrass.

American bullfrogs (*Lithobates catesbeianus*), native to the eastern U.S., are exotic to the western U.S. They were likely introduced accidentally in the early 1900s, during fish-stocking operations conducted by state agencies. Bullfrogs are voracious predators. They will consume any animal they can swallow, including snakes, birds, fish, crawfish—and lowland leopard frogs and their tadpoles.

Like lowland leopard frogs, bullfrogs need to stay wet to survive. In the park, they, too, are confined to tinajas. However, their population also thrives along the margins of the park, in artificial ponds and lakes. During the wet season, bullfrogs move up the wetted washes into the tinajas, where they prey on lowland leopard frogs and tadpoles.

Bullfrogs also carry a fungal disease, called *Chytridiomycota*, or “chytrid fungus.” Although the fungus is not harmful to the bullfrogs, there is some evidence that when bullfrogs enter an environment, they can spread the disease to native amphibians that are vulnerable to it.

Buffelgrass (*Pennisetum ciliare*) is the Sonoran Desert’s greatest enemy. Native to Eurasia and Africa, buffelgrass was intentionally brought to the U.S. in the 1930s for cattle forage. It was selected because of its drought tolerance. Since then, it has spread across the Sonoran Desert.

Buffelgrass grows in dense patches, crowding out and competing with native plants for nutrients, water, and sunshine. Buffelgrass also increases the risk of wildfire, because it replaces bare ground with fuel in the spaces that typically separate native plants (see “Wildfire,” above). This creates a continuous stand of vegetation that helps fire to burn and spread.

Buffelgrass is adapted for regular and frequent burns. It immediately grows back, dominating plant growth and the postfire plant community—and making a bad situation worse.



A dense patch of buffelgrass fills the spaces between native vegetation.

Groundwater Withdrawal

Groundwater is the source of all perennial water bodies in the Sonoran Desert, including seeps, springs, and streams. Groundwater availability is critical to the vegetation and wildlife that depend upon it.

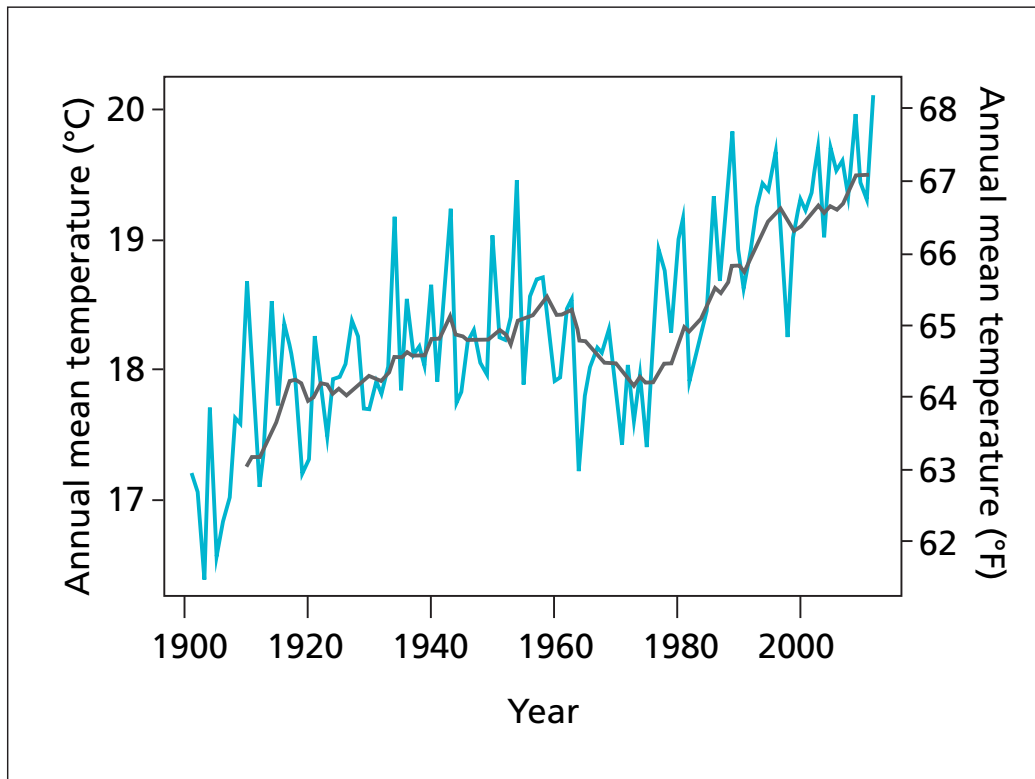
Well-pumping changes the level of the groundwater table. Water flows down-gradient, meaning it will flow from places where the water table is high to places where the water table is low. Pumping from a well pulls water from the aquifer around it. This creates a “cone of depression” that draws water into it from farther away. Much like a straw in a thick milkshake, pumping out water from a well depletes the surrounding water level.

Well-pumping can also deplete streamflow. A well that is up-gradient of a stream can capture water that would otherwise flow into the stream. Similarly, when a cone of depression intersects with a streambed, it pulls water out of the stream and toward the well. When wells are pumping from an aquifer, the water table may drop to a level that makes it unavailable for springs, tinajas, streams, or riparian trees.

In many parts of the desert southwest, long-term drought and human development have led to significant declines in groundwater levels at local and regional scales. Climate scientists predict that the southwestern U.S. will be drier in the future. Although regulations limit the extent of groundwater pumping, excessive pumping may still dry out riparian habitats and streams as human populations increase in the region.



A drying Rincon Creek.



Annual mean temperature at Saguaro National Park has been increasing for the last several decades. The blue line shows temperature for each year. The gray line shows temperature averaged over 10-year intervals. Continued changes in temperature and precipitation are expected to place plants and animals under greater stress.

Climate Change

In 2010, former National Park Service Director Jon Jarvis identified climate change as “the greatest threat to the integrity of our national parks that we have ever experienced.” It is also the greatest long-term threat to water resources in Saguaro National Park.

Saguaro National Park was recently identified as one of the 25 national parks most threatened by climate change. Climate models for the desert southwest have consistently predicted lower annual precipitation, longer droughts, and higher temperatures. Winter storms are predicted to be less frequent and produce less precipitation, and total summer monsoonal moisture is expected to decrease. In addition, storms are expected to be more intense, dropping greater amounts of precipitation in less time. Most importantly, temperatures are expected to increase. Evidence suggests this is already occurring at the park.

If these trends continue and climate predictions are correct, it is reasonable to expect that Saguaro National Park will see a decrease in recharge to the local aquifers that sustain the springs, tinajas, and streams, and to the regional aquifers that provide drinking water.

Climate change will also exacerbate other challenges to water resources. Reduced precipitation and higher temperatures will stress plant and animal communities, putting them at greater risk for wildfire and allowing invasive species to gain a stronger foothold. Furthermore, Tucson may receive less Colorado River water, forcing it to rely more heavily on groundwater reserves and pump greater amounts from the aquifer.

Learning from Loss: The Story of the Santa Cruz

Long before there was Tucson, there was the Santa Cruz River. For thousands of years, water flowing in the Santa Cruz turned the desert into a green oasis. Native fish thrived beneath the surface. Cottonwood and willow trees grew along the river's path, serving as habitat for birds. Mesquite trees stood tall nearby.

The dynamic Santa Cruz often changed its character, cutting channels during floods, then filling the channels with sediment to become a shallow, wide stream. Outside the area that is now Tucson, the river's flow often ceased. But at the base of what is now known as A Mountain, a perennial source provided precious year-round water, supporting riparian habitat and Native Americans for perhaps more than 10,000 years.

A series of natural changes and human impacts quickly changed the character of the river. As Spanish and then Anglo settlers moved into Tucson starting in the 1700s, they demanded more water. During the late 19th century, with the development of the turbine pump, farmers and ranchers were able to pull groundwater to the surface for irrigation. The once-high water table dropped quickly, eliminating many springs and their associated habitats. Large floods cut deep channels. People developed land along the floodplain and further channelized the river to prevent future flooding.

Finally, the Santa Cruz River had nothing left to give. Today, the river is a narrow band of concrete and sand, and many Tucsonans do not know where it is. The Santa Cruz now flows through Tucson only for short periods, when torrential rains fall.

Water supports life, influences culture, and serves as the heartbeat of many communities. When water sources fade, the desert loses an irreplaceable part of itself. For this reason, the value of the watersheds within Saguaro National Park must not be underestimated.



Citizen Solutions

One of Kevin Dahl's favorite experiences is being caught in the Sonoran Desert rain. As he is drenched by a summer monsoon, small, ephemeral waterfalls form around him and the smell of creosote fills the air. Dahl is Arizona's Senior Program Manager for the National Parks Conservation Association (NPCA). NPCA is an independent, nonpartisan group that works to strengthen and protect national parks across the U.S. While Dahl works for the betterment of all national parks in Arizona, he is especially interested in water—specifically, Rincon Creek. With others, he has worked for several years on a bill that would expand the park's boundaries to include parcels of Rincon Creek.

As climate change continues to affect our parks, Dahl says it is important for citizens to band together to support larger solutions. "People within the park service can't lobby, so we do that for them," said Dahl. "We are also a place where people who love the parks can join together. . . . For example, people can join with us [NPCA] in asking Congress to add sections of Rincon Creek to the park. . . . There are opportunities from time to time to make your voice heard." People can support the park and its mission in many different ways. "There are lots of opportunities to volunteer through Friends of Saguaro National Park, directly with the park, or through NPCA," said Dahl. "We need everyone's help."



Recently metamorphosed toad, still tiny compared to a human thumb.



NPS/NIC PERKINS

Water droplets glisten on leaves in Saguaro National Park.



Raising Awareness

Mark Briggs always knew he wanted to work outdoors, for the environment. By doing so, he discovered a love for water. Briggs works for the World Wildlife Fund, focusing on river restoration. Briggs has spent a lot of time studying the water in Saguaro National Park and, specifically, Rincon Creek. He has worked to secure water rights for the park and mapped the water resources of the Rincon Mountains. "Every seep, every water hole, every spring we could find, we mapped. . . . We got to see parts of the Rincon Mountains I had never seen before." Briggs says urban growth and climate change are some of the biggest threats to the park's water resources: "Cities are looking to support their growing, thirsty populations and they are doing it by pumping in areas that should not be pumped." Briggs says that while individual water conservation is a step in the right direction, conservation efforts also need to occur at a broader, landscape scale. That's where conservation groups like the World Wildlife Fund, the Nature Conservancy, and the Sky Island Alliance come in. "These groups are out there trying to protect water for native ecosystems, and this is key," said Briggs. "If you can't protect these limited water resources, it is difficult to protect anything else."

CHAPTER 5

MAKING A DIFFERENCE



Columbine blooms by a waterfall just below Manning Camp.

Protecting a Treasure

The responsibility of protecting Saguaro National Park belongs to all of us—the National Park Service, the park’s visitors, and the citizens of Tucson. The Tucson community fought to create the park in 1933, and to enlarge it in the 1960s. After more than 80 years, the park continues to inspire and sustain us. The water that flows from its peaks is our water, and all of us can play a part in protecting it. No action is too small. You can help protect the park by learning more about its waters, raising awareness in others, and getting directly involved.

Volunteers: Tackling Tamarisk

Invasive exotic plants are one of the most significant threats to natural resources in the national parks today. They can reproduce easily, and quickly colonize new areas. They may also displace native species and alter ecosystem processes across multiple scales. If invasive plants are discovered while their populations are still small, control efforts are likely to be cheaper and more successful than after a species has become more widespread.

A great example of this at Saguaro National Park is tamarisk. Tamarisk is a large tree, native to Eurasia and Africa. It was brought to the U.S. in the 19th century as an ornamental planting. Tamarisk was later used for windbreaks and river stabilization. Today, this plant is overrunning river corridors in the desert southwest. Its extensive root systems draw large amounts of water away from wild-life and native plants. It drops salty leaves to the ground, making it difficult for other plants to grow. In Arizona, many rivers that once supported groves of native willow, mesquite, and cottonwood are now choked with dense stands of tamarisk.

Until about 2005, Saguaro National Park staff only knew of a few tamarisk trees scattered throughout the Rincon Mountains. Only a few plants existed on private property along Rincon Creek. Park staff regularly monitored creeks for signs of the plant and removed any that were found.

Then, in summer 2006, a huge flood ripped down Rincon Creek, spreading tamarisk seeds and stems that quickly began to grow in the wet stream channels. When large numbers of saplings were discovered in the fall, park staff mounted an emergency effort to search for and remove tamarisk plants. During 2006 and 2007, volunteers and interns removed thousands of plants from more than 250 miles of stream channels, while they were still small enough to pull up easily from the roots.

Effectively removing adult tamarisk requires chainsaws and chemicals, and is very expensive. Through this early intervention, the park saved taxpayers approximately \$115,000–\$230,000, and kept its streams from being taken over by this highly invasive plant. Today, Saguaro National Park is virtually free of tamarisk.



Volunteer with a pulled tamarisk plant.

Youth Groups: Parks in Focus

Parks in Focus, a program created by the Udall Foundation, connects youth from the Boys & Girls Clubs of Tucson, Big Brothers Big Sisters of Tucson, and other area organizations to explore nature through photography, environmental education, and creative expression. During a recent field trip,

students spent the day at a group of tinajas in Saguaro National Park. They explored the wildlife that depends on these tinajas, wrote poetry about the importance of water in the desert, and took hundreds of photos. The photos on these pages were taken by group leaders and participants.

PHOTO BY JACOB BRAINERD



PHOTO BY JACOB BRAINERD



PHOTO BY JACOB BRAINERD



PHOTO BY ALE, AGE 11

PHOTO BY CARICIA, AGE 11



PHOTO BY JACOB BRAINERD



PHOTO BY DULCE, AGE 13



PHOTO BY ALEX, AGE 12



PHOTO BY IZEYAH, AGE 10



PHOTO BY ADRIANNA, AGE 13



PHOTO BY DIANA, AGE 10



Dragonfly.

Citizen Scientists: Discovering Mercury in Dragonflies

Buzzing and zipping through grasses and flowers along the water's edge, brightly colored dragonflies use their lower jaws to snatch up anything that moves. Before they become adults, these beautiful insects live underwater, as larvae, for up to five years, eating other small insects and worms. These food sources often contain trace amounts of mercury, a toxic metal.

Mercury is a natural element held within rocks. It enters the environment as a component of air pollution through human activities, such as burning coal, smelting and refining metals, or manufacturing consumer items, such as batteries or thermometers. Carried long distances by winds, mercury eventually returns to Earth's surface through gravity and rain. When it reaches wetlands, a bacterial process converts mercury into a toxic form that can poison wildlife and, in high enough amounts, affect human health.

Dragonfly larvae build up higher levels of mercury than other types of water-dwelling insects. The years they spend developing give them lots of time to prey upon many, many small insects. As the dragonflies develop and grow, the mercury in these insects builds up in their tissue, a process called bio-accumulation. As predators, but also as prey for birds and frogs, dragonfly larvae provide a key link in the food chain. Mercury accumulates and is magnified.

To understand this mercury contamination, Saguaro National Park is working with other parks around the U.S.—and with citizen scientists, often high school students—to collect immature dragonflies. Sampling dragonfly larvae has become an easy, effective method for scientists and park managers to assess the risk of mercury contamination in aquatic ecosystems. These samples are then sent to the University of Maine, U.S. Geological Survey, or Dartmouth College laboratories for mercury analysis. Ultimately, the results from Saguaro National Park and other parks will shed light on ecosystem health by characterizing the risk and potential transfer of mercury through food webs.



Ranger and students at a tinaja.



Student field trip.

Citizen Stewards: Everyday Ways to Help Protect Park Waters

LEARN MORE

- Learn more about the water in Saguaro National Park and the surrounding City of Tucson.
- Engage with water education and conservation programs in the area, such as Project WET (<https://arizonawet.arizona.edu/>) and the non-profit Watershed Management Group (<https://watershedmg.org/>).
- Find out what the Sonoran Desert Network and Desert Research Learning Center are doing to monitor water resources in the park and across the region, and how you can help (<https://www.nps.gov/im/sodn>).
- Get involved with the park's Junior Ranger and Not-So-Junior Ranger programs.
- Visit the park's website to see photos and webcams of water resources (<http://go.nps.gov/sagumultimedia>) and learn about historic water use in the park (<http://go.nps.gov/saguhistory>).
- Teachers, invite a park ranger to your classroom, plan a field trip, or request a Traveling Trunk program (<http://go.nps.gov/sagued>).

CONSERVE WATER AT HOME

- Turn off the tap while soaping your hands and brushing your teeth. This can save around 300 gallons of water a month.
- Water your plants in the morning or night instead of the middle of the day.
- Exchange your water fixtures and toilets for low-flow options.
- Harvest rainwater for plants and outside work. The City of Tucson has a rebate program (<https://www.tucsonaz.gov/water/rwh-rebate>).
- Remove invasive species, such as fountaingrass and buffelgrass, from your yard.
- Replace lawns with low-water native species. You'll conserve water and save on your water bill.



Rainwater harvesting tank at the Desert Research Learning Center.

SUPPORT AND VISIT THE PARK

- Become a citizen scientist by collecting data in the park and submitting it to a large database. There are citizen science projects available for all types of projects from night skies to wildlife spotting. Visit <https://www.nps.gov/sagu/getinvolved/index.htm> for more information.
- Volunteer at the park. Opportunities may include staffing the visitor centers, leading nature hikes, presenting environmental education programs to school and community groups, conducting Junior Ranger programs and day camps, assisting with research projects, day-to-day functions like trail building and maintenance, and patrolling trails on foot and horseback. Visit <https://www.nps.gov/sagu/getinvolved/volunteer.htm> for more information.
- Join a buffelgrass pull. Pulls are held the second Saturday of each month in September–May. For more information, visit <http://go.nps.gov/9vcu97>. There are also pulls organized throughout Tucson and the surrounding region—so if you can't make it to the park, join one in your neighborhood. Contact the Southern Arizona Buffelgrass Coordination Center (<http://www.buffelgrass.org/>).
- Additional research information about Saguaro National Park is always needed.
- Join the Friends of Saguaro National Park, the not-for-profit organization that helps raise awareness and funds for projects within the park (<http://www.friendsofsaguaro.org/>).
- Make your voice heard via the National Parks Conservation Association (<https://www.npca.org/>), the World Wildlife Fund (<http://www.worldwildlife.org/>), Sky Island Alliance (www.skyislandalliance.org), and other advocacy groups.
- Learn which pests to keep out of your backyard ponds and how to identify them. The Tucson Herpetological Society provides information on identifying all types of amphibians and reptiles, including invasive bullfrogs: <https://tucsonherpsociety.org>.
- Visit the park and advocate for it. Experience the landscape firsthand. Ride a bike around the Cactus Forest Loop. Hike the trails to the Signal Hill petroglyphs. Swing by the visitor centers to learn more about this fantastic place.



Citizen scientists help with the 2014 park BioBlitz.



Volunteers pull buffelgrass on Public Lands Day.

Acknowledgements

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Phone: (520) 733-5153

Web: <http://www.nps.gov/sagu/index.htm>

Facebook: <https://www.facebook.com/saguaronationalpark>

Credits

All photos in this document are courtesy of the National Park Service unless otherwise noted. *Front cover:* The Grotto, a large tinaja in Saguaro National Park (NPS). *Opposite:* Water flows over a waterfall in the Rincon Mountain District (NPS/Alice W. Biel). *Back cover:* Tinaja water (NPS/Alice W. Biel).

This book was produced by Janelle Gaun, Emily Huddleston, Don Swann, and Scott Stonum (Saguaro National Park), and Alice Wondrak Biel (Sonoran Desert Network).





The beauty of the desert is its lack of water. Here, the cogs of the ecosystem turn by the power of a few small water drops. This paucity makes each moist crevice of rock, each puddle, each dewdrop a blessing—a critical resource to be wondered at. The waters of Saguaro National Park are increasingly vulnerable, as are the plants and creatures that depend on them. Even small measures can help protect the water within the park. Change begins with us.

