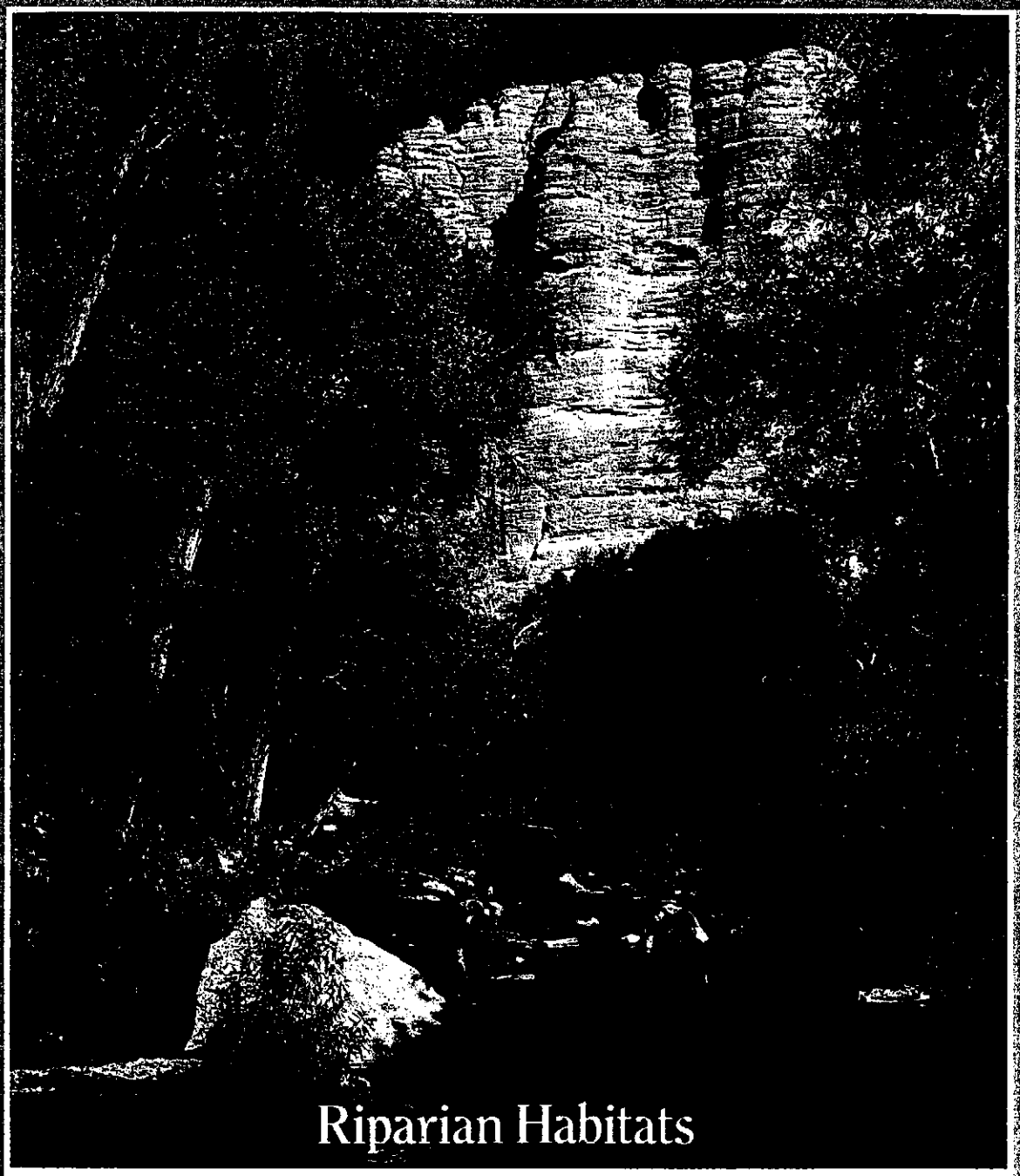
Arizona-Sonora Desert Museum Newsletter Summer 1988

sonorensis



Riparian Habitats

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sonorensis

Arizona-Sonora Desert Museum
Newsletter — Vol. 9, No. 2 Summer 1988

The Arizona-Sonora Desert Museum
Co-Founded in 1952 by
Arthur N. Pack and William H. Carr

sonorensis is published by the Arizona-Sonora Desert Museum, 2021 N. Kinney Road, Tucson, Arizona 84743.

sonorensis is the Latin, scientific term indicating the species classification of many plants and animals of the Sonoran Desert region.

Cover Photo:
Aravaipa Canyon Preserve.
Photo by E. Tad Nichols

MUSEUM NEWS

Directors Club Gala Planned for October

The Directors Club of the Foundation for the Arizona-Sonora Desert Museum is planning its First Annual Elegant Affair scheduled for the evening of Saturday, October 8, 1988 at the Museum. Under the able co-chairmanship of Foundation Board member Curtis Scaife and Mrs. Francis Barrett, the $250.00 per person, black-tie dinner promises to be one of the highlights of Tucson's fall social scene. World-renowned wildlife artist Nicholas Wilson who created the Directors Club mountain lion sculpture will be the guest of honor at the dinner.

Havens elected trustee president for 1988–89

Professor William H. Havens will serve as President of the ASDM Board of Trustees during fiscal 1988–89. Other officers elected by the Board at its first meeting in May are: Margaret G. Twyman, Vice-President; Helen V. Fisher, Secretary; D. Alan Smith, Treasurer; Bernard W. Simons, Jr., M.D., Assistant Secretary; and Lloyd L. Clucas, Assistant Treasurer. Elected by Museum members to serve four-year terms on the Board of Trustees beginning this year are: Mary K. Foster, Lloyd L. Clucas, John R. Hucko, Peter L. Kresan, and William C. Scott.

Elected to serve one-year terms on the Advisory Council for 1988–89 are: Georgiana S. Boyer, M.D.; Ruben G. Fernandez; J. T. Fey; Kenneth R. Harder; Ronald G. Henry; David M. Hyatt; David O. Johnson; Daniel Lopez; Paul Madden, Docent Representative; Theodore A. Riehl; Cabot Sedgwick; Robert L. Smith, Ph.D.; Suzanne Tumblin, Ph.D.; Daniel C. Turner; Josephine R. Voevodsky; Weldon A. Washington; and Wendell E. Wilson, Ph.D.

O'Rielly to sponsor *Desert Speaks*

We welcome Tucson's O'Rielly Motor Company as the Museum's newest CORPORATE DONOR. O'Rielly has signed a contract with KOLD-TV to sponsor the Museum's weekly television program, *The Desert Speaks*, for six months beginning last June. The Museum values this new association with O'Rielly Motor Company and hopes it will be a continuing one.

Yule assumes public affairs post

Lauray Yule, Producer/Co-Host of the Arizona-Sonora Desert Museum's weekly television program, *The Desert Speaks*, was appointed ASDM Public Affairs Officer in mid-June. Yule, who joined the museum staff in August, 1986, will continue her *Desert Speaks* responsibility. Yule holds a B.A. in journalism from the University of Wisconsin with an emphasis on science communications. She has both print and broadcast experience, having served as editor of *Astronomy Magazine*, and Producer/Moderator of a public affairs program at the Public Broadcasting System affiliate in Redding, California. She has produced and co-hosted *The Desert Speaks* on KOLD-TV in Tucson for eighteen months.

Before joining the Desert Museum staff, Yule had been Director of the Schreder Planetarium in Redding, California for four years and was Special Assistant to the Director of Steward Observatory at the University of Arizona for two years.

Yule competed with 190 other applicants for the Public Affairs position at the Desert Museum.

(Continued on page 20)

Director's Report

The Desert Museum is dedicated to the idea that the more people know about the areas in which they live, the more they will appreciate their surroundings and the more they will care for them. The ASDM's regional concept of interpretation — limiting itself to the story of one area — allows its staff and docents to delve into great detail about the interrelationships of the land, plants and animals of the Sonoran Desert region. This is almost impossible at institutions which are charged with broader missions. This concept also places a greater responsibility on the ASDM, because by excluding other regions the Desert Museum is legitimately viewed as being expert on the Sonoran Desert area, and therefore, the leader in educating those who live in this beautiful region about its fragile nature. In this issue you will read about some very special habitats in our region — riparian habitats that are fast disappearing. Something must be done to stop their destruction. You will learn that many of the plants and animals you have grown to love are truly endangered. Although we are able only to acquaint you with riparian habitats in this issue, we hope you will read some of the books we list and then do what you can to help protect these invaluable resources.

The new hummingbird exhibit is under construction and will be completed soon. It will be open to visitors before the end of the year. It is our hope that the renovated Life Underground exhibit will also be open before 1989. Your 1988-89 Board of Trustees and the staff have a full agenda for this year. Your continued support is vital to complete that agenda and on behalf of the Trustees and staff I again thank you for your dedication to this museum.

Dan Davis, Director

Why a Foundation?

You may have wondered "Why a Foundation?" The answer is Stewardship.

What do I mean by Stewardship? I mean the responsible management of all the good things of the universe. The Desert Museum epitomizes one aspect of Stewardship: the protection, conservation, and preservation of the ecosystem in which we find ourselves. Stewardship not only involves present preservation but also education of future generations to continue the Stewardship. The success of the Museum in these areas has been great. The master plan for the Museum is exciting and vital to its mission. The contributions of capital to build these facilities, to annual contributions of time by docents, trustees, and others are invaluable.

However, completion of each capital project requires continuing maintenance, population with plants and animals which in turn must be cared for, fed, watered, and replaced. To the extent that the Museum depends upon admissions, there are two ways to increase revenue: increased attendance or admission fees. The Museum has had several days when the number of visitors exceeded the number which our facility can comfortably handle and provide a good learning experience. There are limits to the number of visitors which the Museum can accommodate. There is a limit to the amount which the Museum can charge for admission because after a certain point the cost of admission becomes prohibitive and exclusionary and the very public which we need to reach and educate cannot avail itself of the beautiful facilities and educational opportunities which we provide.

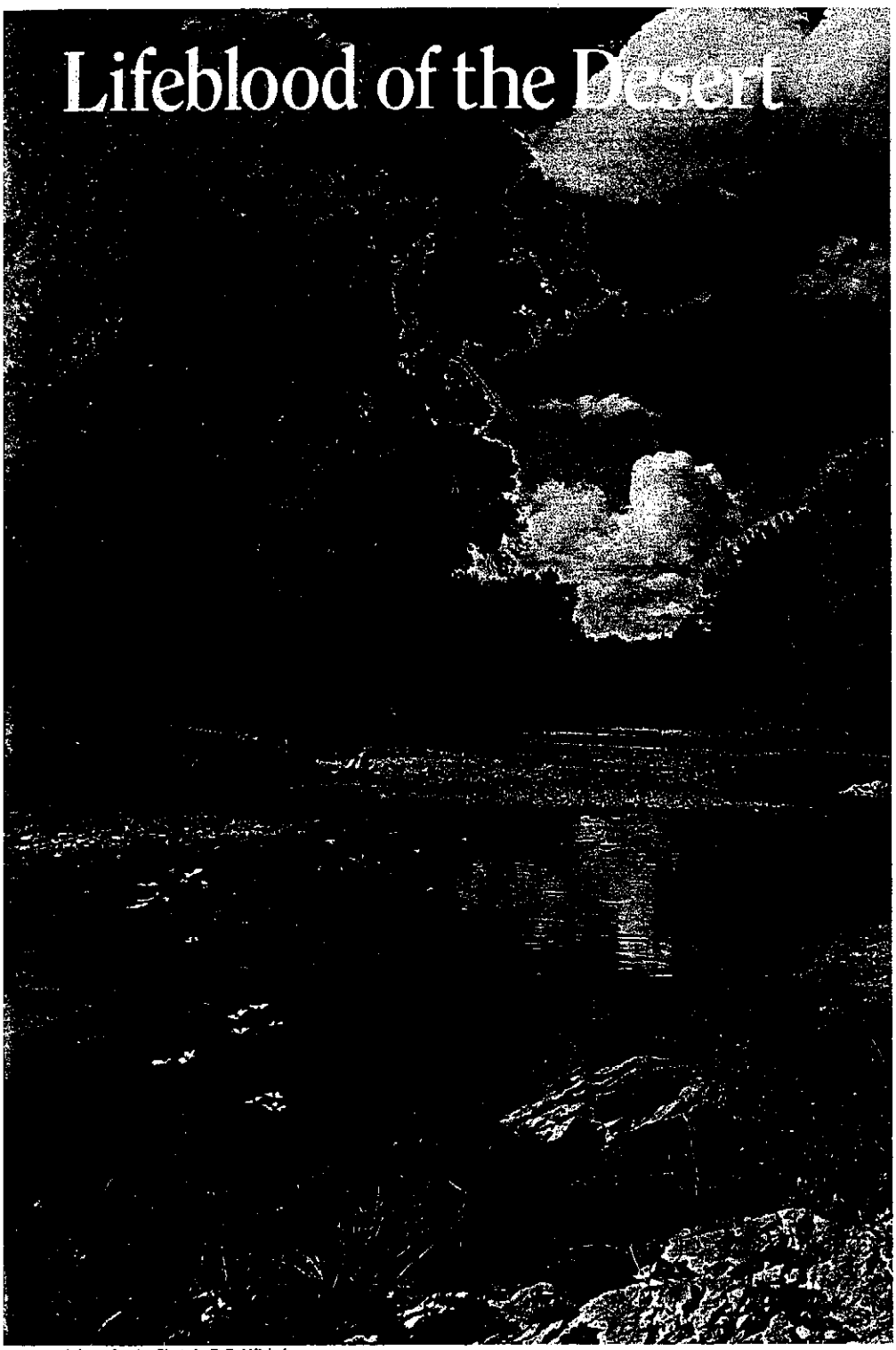
What can we do to preserve and enhance the purpose and program of our wonderful facility without overloading it or emptying it? One answer is our dream for the Foundation. Through diligent labor we can develop a program of planned giving which will combine the gifts of many of us into an endowment fund to provide a continuous income stream to augment the other income of the Museum and meet the operating income requirements of the Museum. Such an endowment income would enable the Museum to keep its admission charges to a minimum and to plow this revenue back into its facilities and programs. Such activities as the First Annual Elegant Affair of the Directors Club, to be held at the Museum on October 8, 1988, will help in creating an ongoing gift solicitation program which will provide the Museum with a group of committed volunteer fund-raisers to assist in soliciting gifts for future projects of the Museum without the necessity of invading the Board designated operating reserves which the Museum's trustees and staff have so diligently accumulated, invested, and preserved.

The answer to "Why a Foundation?" is that another important facet of our responsibility of Stewardship is the adequate funding of the ongoing programs and purposes of the Arizona-Sonora Desert Museum. The Foundation's purpose in building an endowment income for the Museum and in helping to raise the money to complete the Museum's long range master plan is good Stewardship in action.

William C. Scott, President
Foundation for the
Arizona-Sonora Desert Museum

On cloudless, hot June afternoons, Museum visitors are delighted when they discover the beaver and otter exhibit with its deep shade and silver water. Those of us working on the grounds often overhear their expressions of relief and pleasure, and sometimes, too, we hear our visitors wonder aloud why we include this watery exhibit in a *desert* museum. In reality, the streamside, or *riparian*, community represented by this exhibit is the lifeblood of the desert, the wet and lush provider of so much life in our arid land. It accounts for bald eagles and elegant trogons, red bats and river otters, leopard frogs and garter snakes, dragonflies and human beings. Our Museum visitors, standing under the cottonwood canopy, watching streams fall into pools, feel the cool truth of the expression "water is life," though they may not know much about this habitat. Their lack of familiarity is understandable, for while riparian systems are incredibly important, especially in the Southwest, they are rare and very little understood. Until recently, too, they have been little valued in themselves, and so they are vanishing. Because riparian systems are so important, and because they are in such jeopardy, we are devoting an entire *sonorensis* to an exploration of this habitat type.

Lifeblood of the Desert



Arivaca Creek. Photo by E. Tad Nichols

Contributions to this issue were made by Curator of Education, Carol Cochran; Curator of Plants, Mark Dimmitt; Curator of Small Animals, Howard Lawler; Curator of Birds and Mammals, Peter Siminski; Curator of Earth Sciences, David Thayer; and Research Scientist, Tom Van Devender.

Riparian is an adjective, derived from the Latin *ripa* or bank, which means "of, pertaining to, or situated on, the bank of a river." A more comprehensive definition is provided by the Arizona Riparian Council:

> *The term* riparian *is intended to include vegetation, habitats, or ecosystems that are associated with bodies of water (streams or lakes) or are dependent on the existence of perennial, intermittent, or ephemeral surface or subsurface water drainage.*

Though associated with water, riparian communities differ from the aquatic system of the water itself, and we will not include a discussion of aquatic habitat in this article. Riparian systems also differ from the communities on their upland border, which are adapted to drier conditions. Riparian areas are very conspicuous: compared to surrounding areas, they have more vegetation which is also taller and denser; they are usually messier, with ground cover, debris and fallen timber; and they are generally noisier, because they contain more life.

Over much of the temperate and subtropical areas of the Southwest, the same few tree species dominate riparian habitats: Fremont cottonwood, willows, Arizona sycamore, velvet ash, and walnut. At higher elevations alder and some maples become common. Along tropical rivers the vegetation is almost wholly different: figs or Montezuma cypress share the riparian zone with a host of local forest trees. Other trees are opportunistic; they occur in riparian zones at lower elevations than they do elsewhere because of the cooler, wetter habitat. Examples are blue spruce, pines, oaks, junipers, and Arizona cypress.

The composition of riparian areas differs depending on such variables as the surrounding habitat, elevation, slope, or whether the water is a flowing river, a sluggish marsh, or a tiny spring. The riparian area may be only a few inches wide along a steep walled canyon, or it may spread out for a mile or more in a flat river valley. Examples of common riparian areas within our region are portrayed on pages 6 and 7.

Evolutionary History

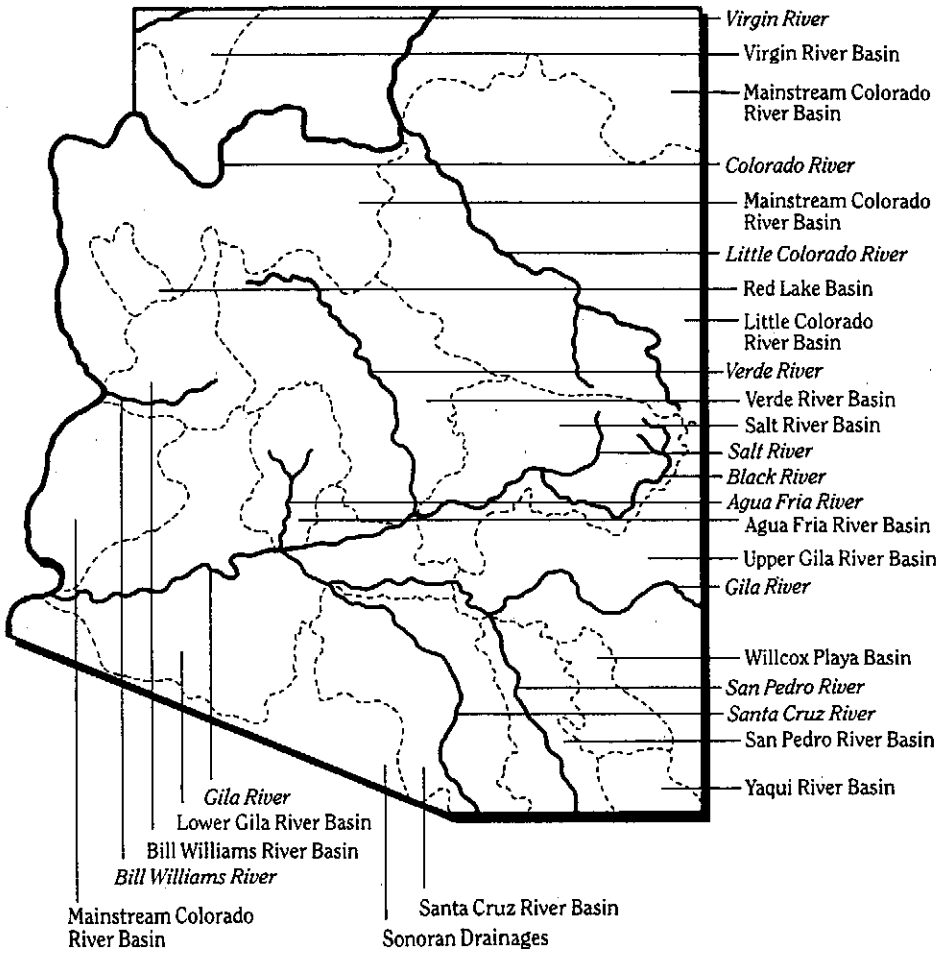
Riparian plants are ancient. They grew in the Sonoran Desert region long before there were saguaros or palo verdes or even mesquites, because before it was desert, our landscape was covered by tropical rain forests, vast wetlands, and giant water courses. About 100 million years ago, the first angiosperms, or flowering plants, evolved as shrubby weeds in the disturbed areas along the streams which ran through conifer forests. As they came to drink, about 65-75 million years ago, dinosaurs trampled the ancestors of cottonwoods, willows, walnuts, and sycamores. Interestingly, many of these modern trees resemble their herbaceous ancestors in depending on wind pollination and dispersal of seeds by wind or water rather than by animals, a trait which has kept many of them ever dependent on occasional flooding. Riparian plants were old when birds and mammals began to proliferate 65 million years ago.

A period of mountain building 10-25 million years ago culminated in additional uplift of the Rockies and the Sierra Madre. This uplift permanently changed the climate and formed new vegetation types including cool montane conifer forests, grasslands, and hot desert. Wherever there was at least occasional water, riparian zones were created in each biome: older riparian plants, such as willows or alders, grew at the cooler, wetter mountain streamsides in the canyons; legumes such as mesquite and acacias could be found along desert washes; and in the lowest, driest areas typical desert plants such as the saguaro or palo verde (which probably evolved with the Sonoran Desert itself, only 5-8 million years ago) could find enough moisture only in washes. Thus a desert riparian walk from higher to lower elevation is a journey through geologic time, from the Age of Dinosaurs to the present.

Water

Riparian areas have been the arena for dramatic evolutionary change. This is appropriate as they are themselves dynamic systems which maintain their stability in the face of, and often because of, change. Among the most dynamic occurrences in a riparian system are

Major Rivers and Drainage Basins



floods and erosion. Riverine wetlands and their floodplains are natural courses that convey floodwaters. Those who have seen a normally dry desert wash "run" following a heavy rainstorm somewhere along its drainage know the tremendous power of a flood. Tucsonans remember the 1983 flood of the Santa Cruz River following a six-day storm. The peak flow along the Santa Cruz was over 60,000 cubic feet per second (twice the typical discharge of the Colorado River in the Grand Canyon). The flood waters destroyed buildings, power lines, sewage crossings, and caused $100 million damage to roads and bridges.

Riparian areas themselves are greatly impacted by flooding. These effects include removal of trees, floodplain scour with loss of soil and plant understory, migration of the channel, rearrangement of sand and gravel bars, introduction of silt and clay during recession of flooding, and channel scour down to bedrock. In effect, major floods "reset the clock" on development of mature (climax) riparian ecosystems, continually rejuvenating the systems by requiring them to start over.

The story of flooding should not stop with a statement of its destruction, for the issue is more complex. First, riparian areas do not merely convey floodwaters, but they can also control and reduce flooding. Structures within the floodway can block flows. Marshes or wetlands or open floodplains along a channel may store water during times of flooding and slowly release it downstream. Riparian vegetation can decrease flood peaks and can bind and stabilize soil with its root systems.

Secondly, flooding, which has always been a component of a riparian ecosystem, has benefits. A case in point is the Fremont cottonwood, perhaps the

archetypal riparian tree, and certainly the most studied. It is an obligate riparian species (meaning that it can live in that habitat and nowhere else) because it requires lots of water. A mature Fremont cottonwood tree transpires 100 gallons of water a day. It grows very fast, to more than 100 feet tall, and attains a trunk diameter of up to six feet.

The seeds of cottonwoods are viable for only a few weeks following their release (between February and April depending on elevation) and can germinate only on new, wet sandbars deposited by receding spring floods. Deposition of sandbars is in turn dependent on upstream erosion; more erosion produces more deposition downstream, which provides more seed bed area for establishment of cottonwoods.

In most plants, germination occurs under the conditions most likely to ensure survival to maturity; the opposite is true of cottonwoods. The only place they can germinate is also the most likely place to be scoured by subsequent floods; survival of seedlings is thus very low. At sites more distant from the edge of the stream channel survival is more likely, but germination is low because of the usual lack of the required saturated soil. Cottonwoods are therefore rare along main stream channels, and most abundant along secondary "overflow" channels where scouring occurs less frequently.

The roots of cottonwoods must be at the surface of the water table, but cannot tolerate long inundation. Therefore, cottonwoods cannot survive in such places as reservoirs, where the water level fluctuates greatly — the trees either dry out or drown.

The seeds of such riparian trees as sycamore, ash, walnut, or alder need moist burial, but do not require recently deposited sandbars. However, willows, as well as cottonwoods, are dependent on flooding for seed germination. Some animals also need the sandbars produced by flooding for successful reproduction. For example, the Rio Yaqui and Rio Fuerte sliders, two aquatic turtles native to Sonora, build nests in the sandy banks created by flooding. Dams in the region have reduced flooding, and the lack of suitable nesting sites may be causing the Rio Yaqui slider to decline in some portions of its range. Flooding is just one of many interactions among the living and non-living components of a riparian system.

Riparian ecosystems could not exist without permanent sources of water. But water sources are scarce in the Southwest because of scant rainfall and a startling evapotranspiration rate. (Evapotranspiration is the total loss of water to the atmosphere, including natural evaporation and transpiration from plants.) *Potential* evapotranspiration exceeds annual precipitation by a factor of almost ten. It is obvious that little water remains in the soil under such conditions. In fact, groundwater recharge can only be accomplished by long, slow, ground-soaking rains. These are most characteristic of winter rains in the Sonoran Desert.

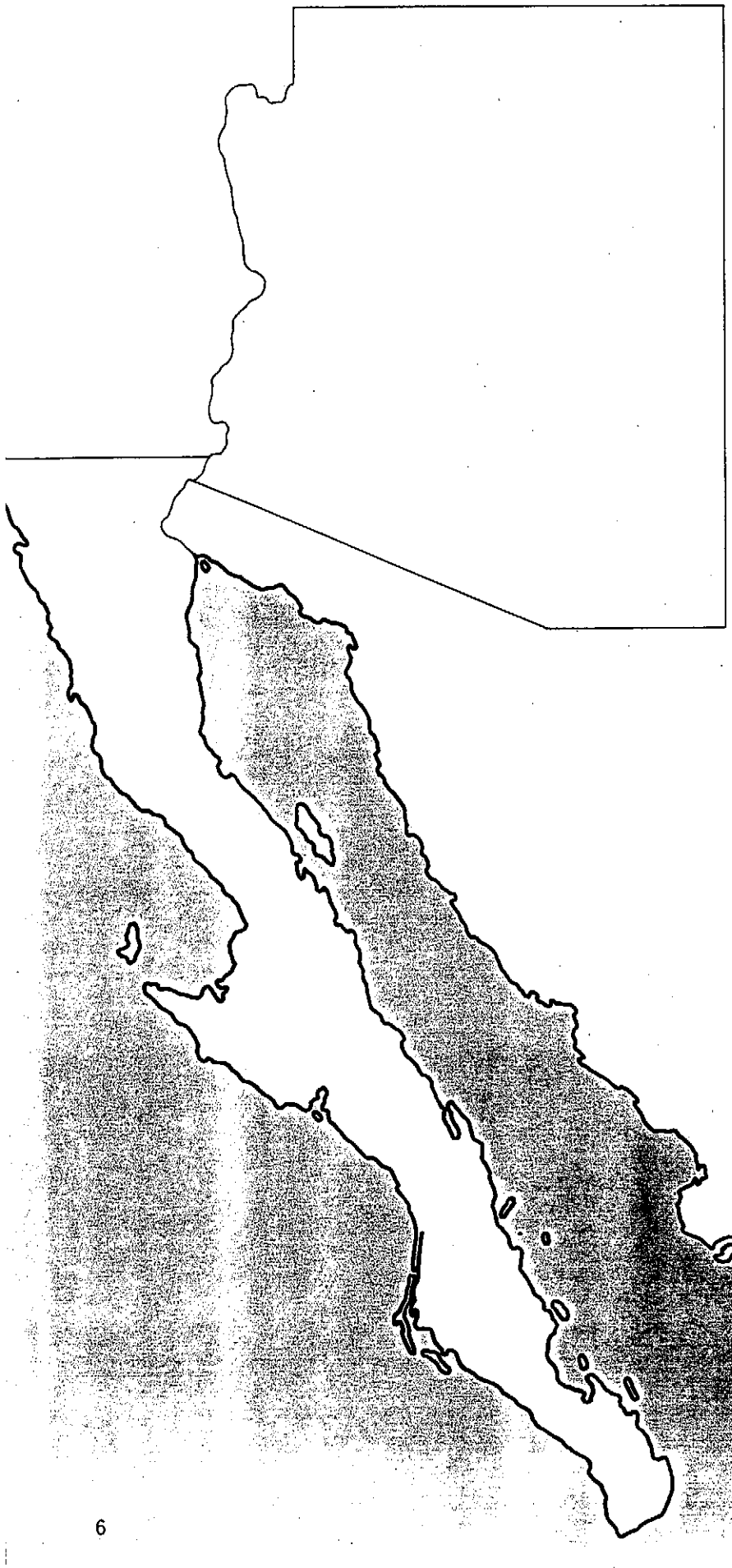
Since most of our rain comes bimodally during the summer and winter, there must be a mechanism for supplying a relatively steady flow to our uncommon perennial streams. This is accomplished by groundwater infiltration and relatively steady spring discharge rates which tend to smooth out the seasonal variations in precipitation.

Where a water table intersects the ground surface as at springs, cienegas, and flowing artesian wells, there is a reliable water source. The groundwater can be viewed as reservoir that is recharged sporadically, yet supplies water continuously to surface runoff systems. Local geologic conditions may prevent groundwater from infiltrating to greater depths. This is usually an advantageous situation, especially in the desert. Such conditions include perched water tables, where the groundwater reservoir occurs in an aquifer (porous sediment or rock) above a non-permeable layer called an aquiclude.

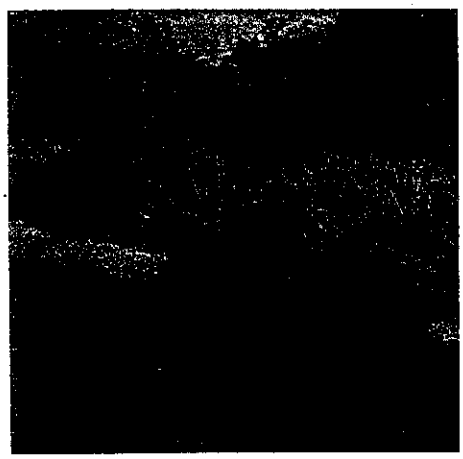
Fremont cottonwood tree

Cassandra Krause, The Nature Conservancy

Common Riparian Types



Mark Dimmitt



Howard Lawler

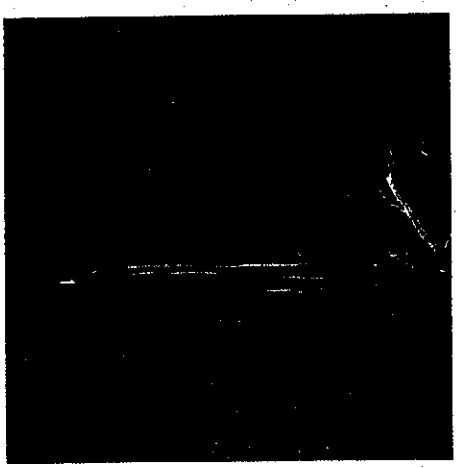
Howard Lawler

Montane Stream: Cave Creek
The montane stream is characterized by steep slopes and fast-running water, often in cascades and waterfalls. Its riparian zone is usually narrow because the stream has cut a canyon with steep sides. The surrounding habitat is usually a forest or woodland, but the riparian zone has different species of trees and is thus distinguishable even if the stream is not visible. Typical trees are willows, alders, bigtooth maples, and below 6,000 feet, cottonwoods, and sycamores.

ASDM photo

Lakes or Ponds: Quitobaquito Spring
Bodies of still water may have riparian edges. The vegetation beside lakes and ponds depends primarily on elevation and on how much the water level varies with the season. Artificial reservoirs which draw out much water during the dry season and thus have large water level changes may have very little riparian vegetation. Reservoirs with stable water levels will develop the same vegetation as natural lakes in the area.

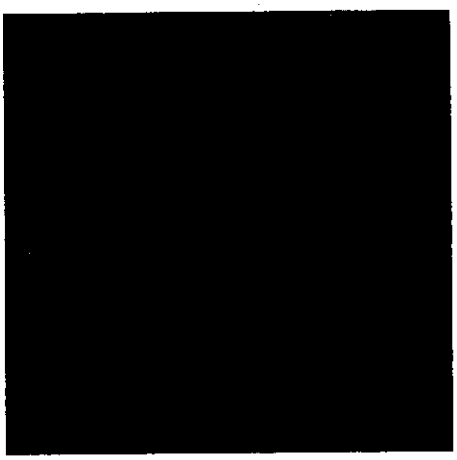
Desert River or Stream: Salt River
The desert river or stream is typically on gently-sloping to nearly-level ground, at lower elevation than that of the mountain stream. Its riparian zone may be very narrow if the stream is cutting through a mountain range (e.g., Aravaipa Canyon), or quite broad on valley floors (e.g., the floodplain of the Colorado River). The riparian zone's lushness contrasts sharply with the adjacent desert's aridity. Typical trees are cottonwoods, sycamores, willows, and velvet ash.



Jeanne Broome

Intermittent Streams: Tanque Verde Wash
In arid places like the Southwest, the term riparian *includes not only habitats along perennial streams, but also those stretches of stream which carry water seasonally, during the period of highest rainfall or snowmelt in their headwaters. The riparian zones of intermittent streams have many of the same plants that occur along the permanently flowing stream uphill, though they are smaller and less dense.*

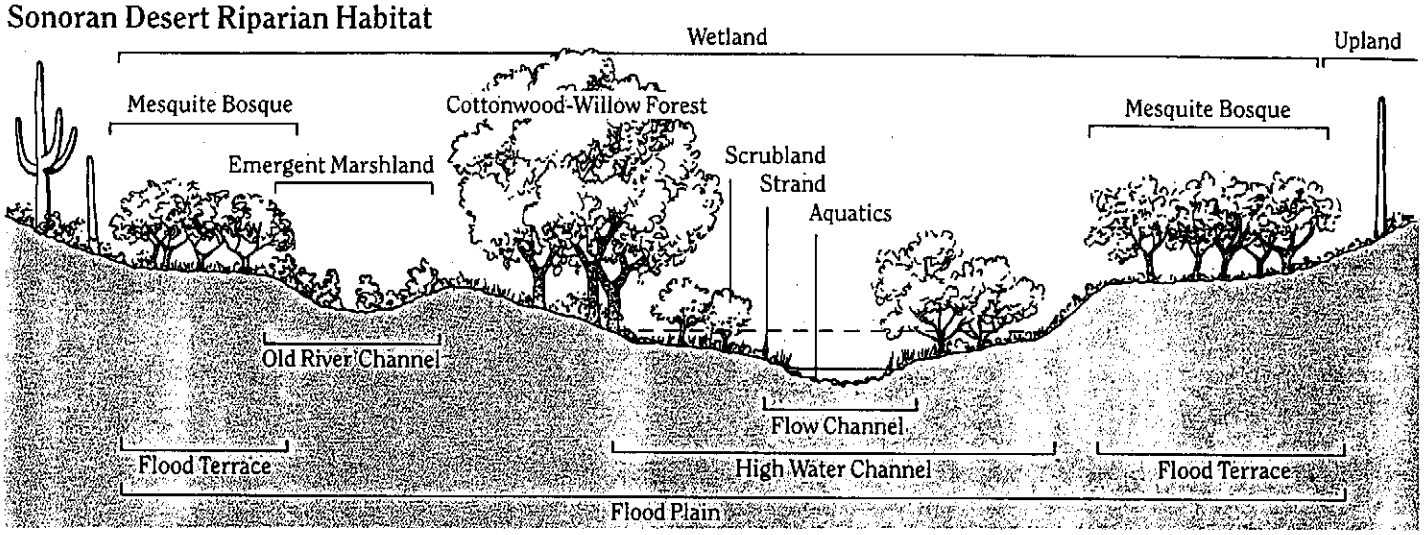
Tropical Stream: Rio Cuchujaqui drainage
A tropical stream may be in the mountains or lowlands; it differs from the temperate and subtropical areas in being essentially frost-free. Its vegetation is therefore tropical; its riparian areas are characterized by evergreen broadleaf species: figs, Montezuma cypress, willows, and tropical hackberry. Much of tropical riparian vegetation is the same as that on the slopes. Thus, unlike other riparian systems, tropical riparian habitats do not differ substantially in plant species from their surroundings.



Mark Dimmitt

Dry Wash: Chuckwalla Valley, CA
The dry desert wash, or arroyo, is an extreme example of riparian habitat. Although it may be dry for all but a few hours a year during flash floods, the wash collects runoff from large areas and so contains more moisture than the adjacent desert. The dominant trees in a wash are desert ironwood, blue palo verde, velvet mesquite, and desert willow. In the drier regions of the desert, these trees occur only along wash channels.

Sonoran Desert Riparian Habitat



Soil

In contrast to neighboring desert soils, Southwestern riparian soils can support luxuriant plant growth. It is easy to see why. There is abundant water to leach the salts from the soils. Compared with the surrounding desert, soils are thicker and richer in organic matter due to denser vegetation. Beneficial elements that would be leached from a tropical soil, for example, are periodically replenished here by runoff from the surrounding mineral-rich desert, and organic nutrients are transported from lusher elevations with greater rainfall. Good soils, plenty of water, and our famous southwestern sunshine combine to optimize plant growth conditions.

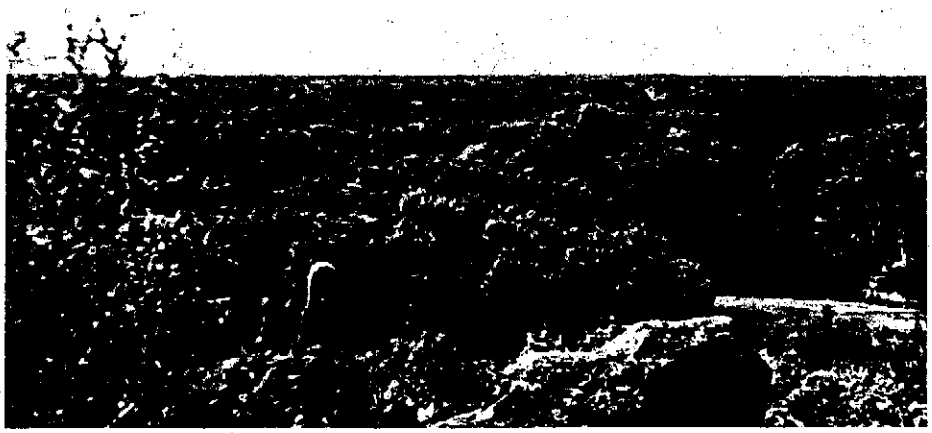
Human Impacts on Riparian Areas

Over the past 100 years, the arid Southwest has changed in many ways. Perhaps no change has been so striking or sad as the loss or degradation of its waters and their bankside communities. Recent books such as *Once a River* and *A River No More* document the death of our rivers. Studies of habitats show that only 5-10% of the Southwest's original riparian areas remain, that they are among the rarest of all North American forest types, and that they are increasingly threatened.

Those who came to the Southwest in previous centuries knew river valleys that were greener and wetter than they are today. The Hohokam of Snaketown along the Gila River decorated their pottery with pictures of waterbirds, often in the act of swallowing reptiles and fish. In 1699, Father Kino wrote of the lower Gila and its people, "All its inhabitants are fishermen, and have many nets and other tackle with which they fish all the year, sustaining themselves with the abundant fish and with their maize, beans, and calabashes." These wet and productive valleys are now mostly dry.

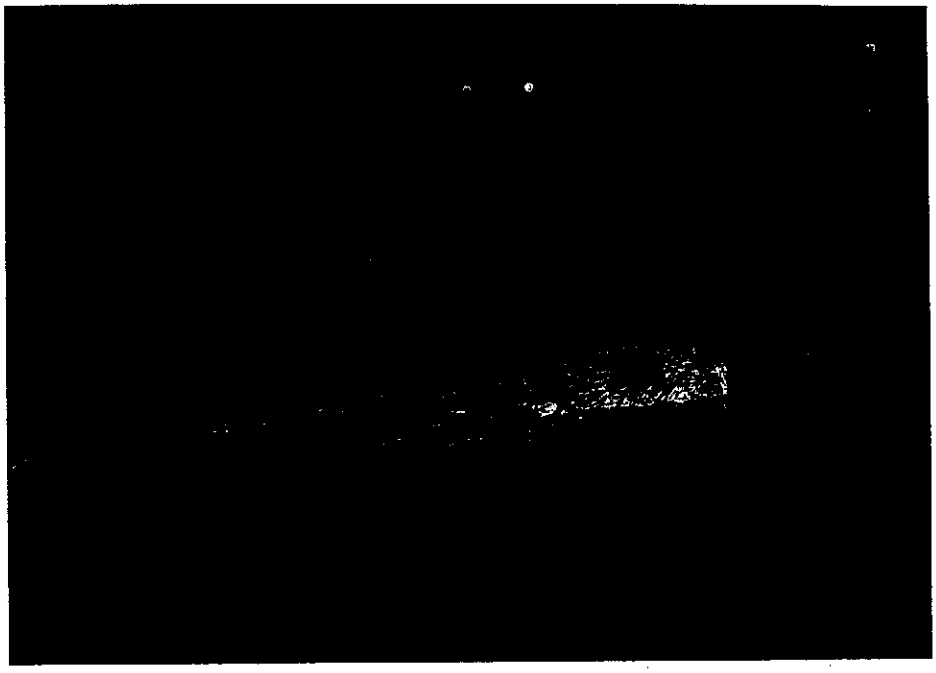
In 1833 a young trapper, James Ohio Pattie, pitched camp in a thick grove of timber along a river 100 yards wide. Beyond the river was a small lake noisy with ducks and geese. In the river, he trapped 200 beaver in seven days. This river, which he called Beaver River, was most likely the San Pedro. Today this same stretch of the river holds no water, timber or beaver.

One hundred years ago, most of the streams and rivers of southern Arizona, including the San Pedro and Santa Cruz, moved slowly through very broad, unchannelled courses; they were perennial, though some, like the Santa Cruz, went underground for long stretches. Cotton-



AGFD photo.

Santa Cruz River, June 1942
This photo was taken looking south from Sahuarita Butte, now called Martinez Hill (USGS stake #937). Riparian vegetation is dominated by a cottonwood forest in the foreground and dense mesquite bosque in the background.



Beaver
Beaver played an important role in the perpetuation and modification of desert riparian habitats. They built dams, impounded water and thus reduced the rate of stream flow, raised the water table, and increased sedimentation rates. In Arizona, the beaver is still found in the Colorado River and the perennially flowing area of the Gila and Salt Rivers.

wood, brush, mesquite bosques, or marshes lined the rivers. The valleys were filled with grass, cienegas, and pools. Beaver dams were numerous, and fish abundant. Changes occurred, as they always do in a system as dynamic as a river, but beginning about 1890, truly drastic changes began. Consistent streams became intermittent, and channels went dry for most of their reach, most of the time. Once-broad water courses became steep trenches for fast-moving water; the water table dropped; marshes and cienegas dried up; vegetation disappeared; irrigation ditches could not receive water; soil eroded. In *The Changing Mile*, Rodney Hastings and Raymond Turner document these events on the Santa Cruz, using early records and photographs.

The causes of death or decline of our rivers are many and much debated. The southern rivers such as the Santa Cruz and San Pedro may have been altered by exceptionally severe floods during the last 100 years and also by drier conditions, themselves the result of a regional climatic change. Although the dynamics of weather may be a chief cause of the arroyo cutting of the Santa Cruz, most often humans are implicated in the destruction of a riparian system.

Humans have always lived along rivers, particularly in arid places where the waters are life. By the end of the last century, every running stream and permanent spring in Arizona was occupied. People have used rivers and wetlands to maintain life-styles often at variance with the land. We have lived *along* rivers, but not *with* them, and our uses have killed them.

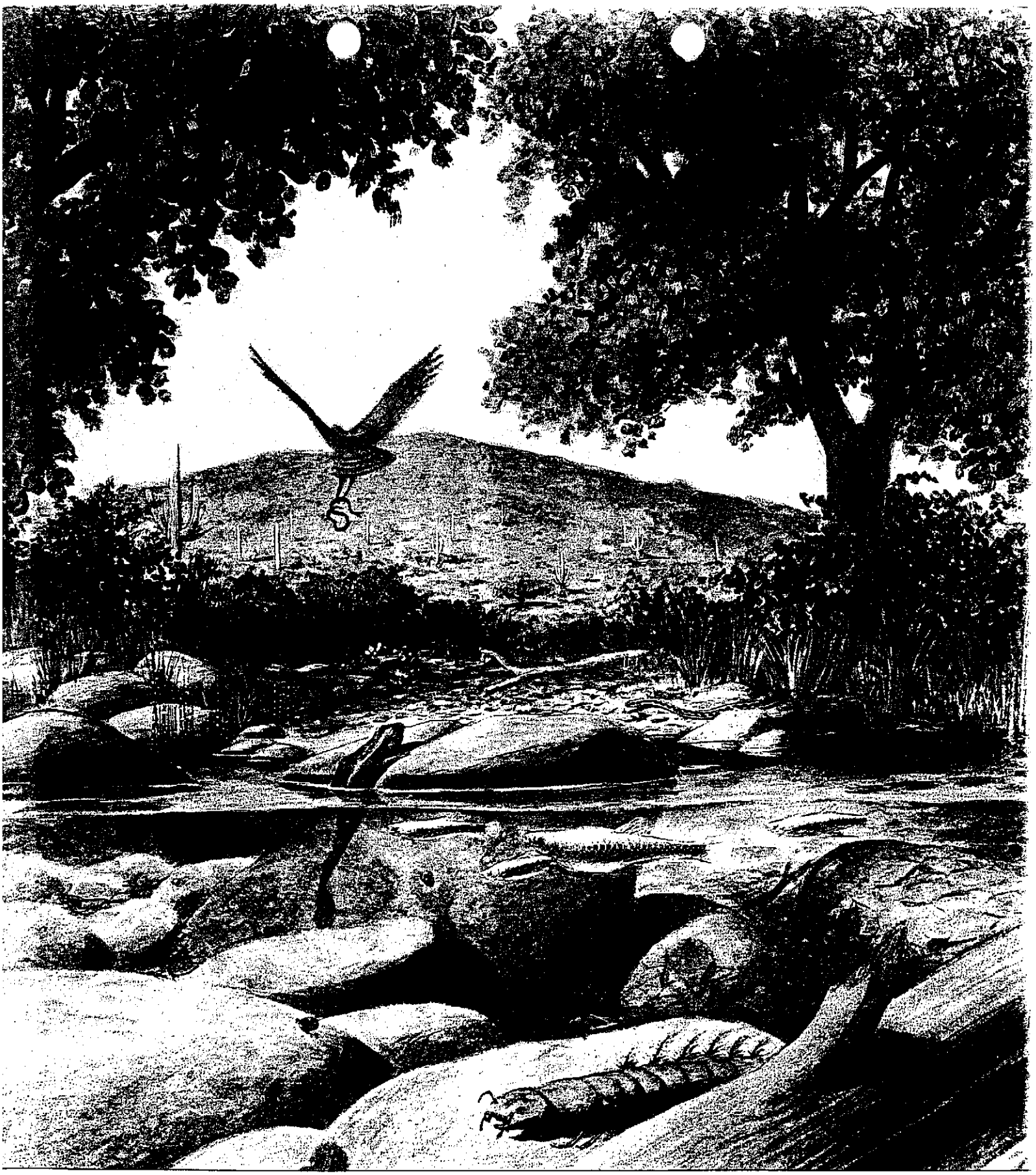
Ever since the Spanish introduced them to the Southwest, cattle have been grazed in riparian areas, ideal providers of food, water, and shade. Because they eat seedlings, cattle can prevent the reproduction of cottonwoods and other riparian plants, resulting in woodlands of even-aged, and aging, trees. Extensive grazing can cause erosion and degradation of water quality, impacting fish and other wildlife. Riparian areas have been the source of timber for building and for fuel.

The water in rivers and streams has been "salvaged" for irrigation of farmlands, for mining and other industrial uses, and for human consumption and recreation. Dams flood riparian areas above them, trap nutrients and sediment, desiccate the wetlands below, and change the flow and temperature of the stream

(Continued on page 12)

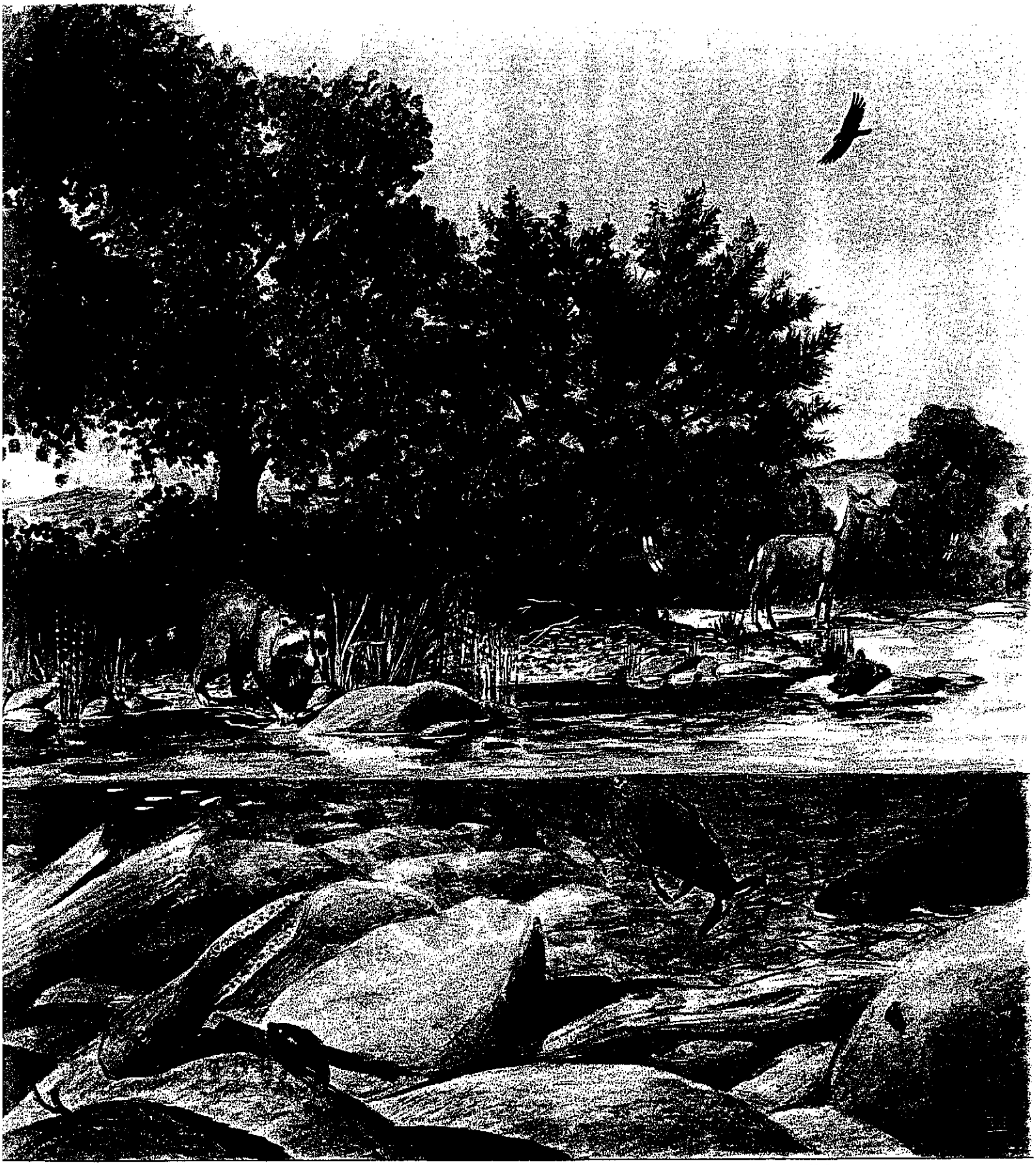
R. M. Turner

Santa Cruz River, same view, June 1981
Note the increased width of the sandy channel, high eroded banks, absence of cottonwood trees, and scattered mesquite.



Warbler
Hawk
Leopard frog
Native topminnows
Dobson fly larva (Hellgrammite)
Garter snake
Summer tanager
Cottonwood trees
Wild grape vine

A Typical Riparian Habitat



Tent caterpillar webs *Vulure*

Desert willow

Raccoon *Grasses and horsetails* *Dragon fly* *White-tailed deer*

Sonoran mud turtle

Leopard frog tadpole *Aquatic snail* *Giant water bug* *Razorback sucker*

for a long way beyond. Other water salvage projects divert water from streams to channels or remove water-using streamside plants. Urban development has filled watercourses and marshes with garbage, parking lots, and buildings. Traffic moves across roads and bridges which partition woodlands with concrete barriers. Development in the floodplain is protected from flooding with dams and levees, and with channelized, dredged, straightened, paved or devegetated watercourses. When overbank flooding is prevented, plants like the cottonwood, whose ecology depends on floods, cannot

Cienegas — Vanishing Riparian Habitats

Spanish explorers of what is now the southwestern United States applied the term *cienega* to marshes found in riparian habitats. These are wet areas near springs or along streams where the water table permanently intersects the surface. Cienegas trap organic materials and nutrients and develop highly organic, reducing soils. The vegetation is often a dense mat of sedges and grasses with aquatics in open water and trees such as cottonwood and willows along the edges. Cienegas are extremely productive ecosystems that support wildlife in much greater abundance than the surrounding slopes. Fishes, amphibians, the Sonoran mud turtle, garter snakes (especially the Mexican garter snake), marsh birds, and wading birds are riparian obligates that for at least some part of their life cycle need this habitat.

Large mammals, especially grazing herbivores, often concentrate near cienegas. Overuse by cattle has been a major source of disturbance historically. Large predators such as the grizzly bear and mountain lion were often seen in them. Cienegas support dense rodent populations, especially cotton rats, and their predators.

Our cienegas typically are found in grasslands and woodlands at 3500 to 5500 feet elevation in the southeastern corner of Arizona. Today cienegas occur at San Bernardino Ranch in the Rio Yaqui drainage, Hooker Cienega in the Sulphur Springs Valley, and St. David, the Babocomori River, and O'Donnell Cienega in the San Pedro River drainage. The rare Canelo lady's tresses orchid occurs in the O'Donnell Cienega which is now protected in The Arizona Nature Conservancy's Canelo Hills Preserve. Cienegas in the Santa Cruz River drainage include several areas near its headwaters, especially Sheehy Spring, in the San Rafael Valley east of Nogales, and the Arivaca Cienega near the town of the same name. Marshy habitats were apparently found in the Tucson area along the Santa Cruz and Rillito Rivers well into this century.

Doug Koppinger

Babocomari Cienega.

People have long been attracted to cienegas. Excavations near Naco in the Sulphur Springs Valley, and at the Lehner Ranch and Murray Springs near Sierra Vista in the San Pedro River Valley yielded the elegant fluted projectile points of the Clovis Culture amongst and imbedded in the bones of the extinct Columbian mammoth. Pollen analysis of the dark, organic sediments containing the bones indicates that cienegas were more common and better developed 11,500 years ago under cooler, wetter ice age climates than today.

Indigenous peoples continued to live near cienegas in Arizona and Sonora into historic times when "rancherias" of the Apaches, Sobaipuris, Pima Altos, Opatas, and Pima Bajos were frequently encountered. From 1692 to 1697 Padre Francisco Eusebio Kino and other padres visited the Sobaipuris along the San Pedro River just east of the Clovis kill sites and estimated a population of 2000 people living in 14 villages.

Beginning in the 16th century, the Spanish and their agricultural and grazing practices increased, and gradually displaced the earlier inhabitants. As early as 1687, Pima Indians at Remedios, Sonora, were complaining that the Spanish pastured so many cattle that watering places were drying.

Anglo-American settlers in the late 1800's and especially this century had a much greater effect on cienegas than earlier peoples. Widespread arroyo cutting in response to the combined impacts of heavy grazing, increased ground water use, and unfavorable climates dried many streams and modified cienegas. Some like the Water of the Dead, a few miles above Aravaipa Canyon, have disappeared without a trace. In others like the San Bernardino Cienega east of Douglas, the area of the sedge marsh has shrunk as cottonwoods and willows declined and velvet mesquite invaded.

reproduce, and a dynamic woodland becomes a senescent grove. Deepening river channels, a plunging water table, and the drying of streams mean that even plants with long roots can no longer reach water, and forests die.

While changes in the flow regime and mineral content of streams have negatively impacted native vegetation, they have made life easy for the salt cedar or tamarisk, a species which was introduced from Eurasia and is now the dominant vegetation along many riparian systems (such as the Salt River) where it has eliminated native vegetation like cottonwood and willow, while providing little value to wildlife.

Biodiversity

In destroying Southwestern riparian communities, we are destroying areas with a biological value completely disproportionate to their size. At least 75% of all Southwestern vertebrate species depends in some capacity on streams and wetlands, yet these areas occupy less than 0.5% of the land mass. A few statistics on birds convey the amazing abundance and diversity found in an Arizona riparian system:

- Riparian areas can contain up to 10.6 times as many spring migrants per hectare as found on adjacent non-riparian habitats.
- Of 134 breeding bird species in the Sonoran Desert, 37% are totally dependent on riparian areas.
- The 1,059 pairs of breeding birds found on less than 100 acres of cottonwood gallery forest along the Verde River in central Arizona is the highest breeding bird density found anywhere in the continental U.S.

R. L. Glinski

Black hawk nestlings

Riparian communities contain so many kinds of birds and other animals because the plant community is so diverse. The crowded conditions of a good riparian forest create many microhabitats (specific local conditions): this variety allows many kinds of animals to perform their unique niches, or roles, within the ecological community.

Many microhabitats can be found in the vertical layering of the tall streamside vegetation and in the horizontal gradation of vegetation as the riparian forest grades to the upland desertscrub in one direction and to the aquatic habitats in the other. A gray hawk places its nest in the tall cottonwoods of the riparian forest and then hunts the whiptail lizards that occupy the bordering desertscrub. The common black hawk also nests in the tall cottonwoods, but it hunts in the aquatic habitats for fish and frogs. Each hawk species has its own niche within the desert riparian community.

Niche separation among the insectivorous birds of the tall riparian forests is even more dramatic. Summer tanagers and yellow warblers will feed and nest

Mark Dimmitt

Sycamore trees growing along the South Fork of Cave Creek. Sycamore bark peels in a distinctive jigsaw-puzzle-like pattern.

high in the canopy of the cottonwoods. Bewick's wrens will glean insects from the trunks of these huge trees and from the rubble of fallen logs and dead brush shaded by their dense canopy. Lucy's warblers nest in the recesses of the peeling bark of a cottonwood or mesquite and then glean insects from the foliage in the bordering mesquite bosque. Yellow-billed cuckoos and yellow-breasted chats occupy the very dense borders between the riparian gallery forest and the surrounding scrub. There the cuckoo crawls through the branches searching for insects on foliage or bark. The thick-billed kingbird catches flying insects on the wing in desert riparian habitats. This flycatcher may nest on the upright limb of a tall sycamore tree. The northern beardless tyrannulet will hide its tiny nest in a clump of mistletoe or even inside the web of colonial caterpillars found in the riparian woodland. Many microhabitats and diverse niches provide for diversity of avian life in a desert riparian ecosystem.

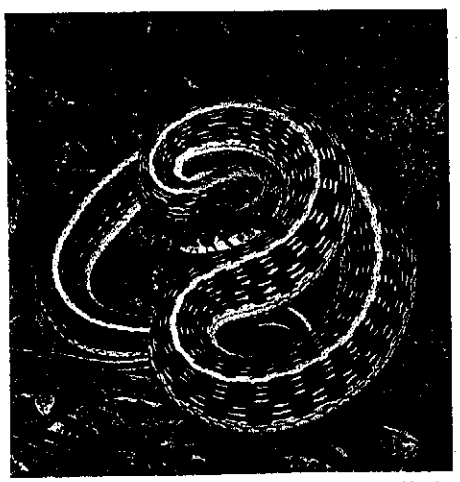
John H. Hoffman

Lucy's warbler

The abundance of birds is dependent upon the amount of food available. Or as an ecologist would say, the biomass of the consumers in a ecosystem is dependent upon the productivity of that ecosystem. For example, the greater the mass

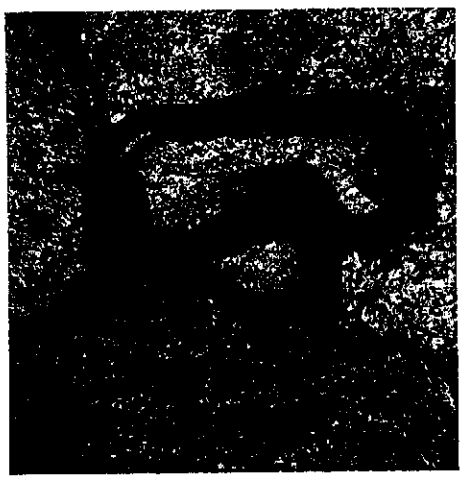
Howard Lawler

Northern Casque-headed Tree Frog
Woodcutting and overgrazing have denuded the margins of some cienegas and permanent ponds, eliminating critical cover for many reptiles and amphibians. The Great Plains narrow-mouth toad, the Sonoran green toad, and the northern casque-headed tree frog share a limited distribution in the mesquite desert-grasslands of extreme south-central Arizona. While their natural habitats may be jeopardized by these factors and groundwater pumpdown, these species adapt readily to artificial breeding sites such as roadside ditches, a versatility which may insure their survival.



Howard Lawler

Black-necked Garter Snake
Garter snakes are derived from water snakes. Although they have become more versatile than water snakes and can often leave the immediate vicinity of permanent water, in the Sonoran Desert region they are riparian obligates, and many are declining along with their habitat. Most garter snakes resemble this one, having three body stripes on a green or olive drab background.



Randy McCranie

Narrow-headed Garter Snake
In appearance and habits, this garter snake closely resembles water snakes and, in fact, has been classified as such in the past. It is highly aquatic, rarely found far from permanent water. Its strange-looking, narrow head is a specialization for catching and eating fish and amphibians. It is becoming rare in some areas, probably due to habitat modification and introduction of predatory game fishes. Healthy populations still occur along Oak Creek above Sedona, and along the Black and Blue Rivers further east.

of plants produced, the greater is the mass of insects, and consequently, the greater is the mass of insectivorous birds. The productivity of desert riparian habitats greatly exceeds that of the adjacent desertscrub.

In addition to the role desert riparian habitats play in supporting a diverse and dense breeding bird population, these habitats are also of great importance to migrating birds. In fact, as these migrants move through the Sonoran Desert, these rare riparian areas may be the only sites for them to feed or rest. Also many northern granivorous sparrows spend the winter in Sonoran Desert riparian habitats feeding on the abundant seed crop produced by the forbs and grasses of this community.

Another feature of those desert riparian habitats that extend out of the higher mountain ranges is the extension of moist and cool habitats into the desert. These extensions of mesic habitats bring some of the birds that may range more widely in the mountain forests and woodlands. The white-breasted nuthatch is such a bird. In the desert, it is only found in riparian habitats. In the high moist mountains, it is more widespread.

Much of what can be said for birds can also be said for mammals, reptiles, and amphibians. The great productivity of the desert riparian community attracts both prey species and their predators. Desert riparian communities support a large population of desert cottontails and therefore many bobcats or gray foxes.

Many snakes enter riparian zones from time to time in search of prey. The tropical vine snake reaches its northern range limit in extreme southern Arizona. Here, most records have come from riparian canyons and the nearby slopes. This slender snake is aptly named, spending much of its time in shrubs or trees where it rests motionless, waiting patiently for its prey of lizards, insects, and occasionally small birds and rodents. Its mild venom is delivered with grooved fangs located in the rear of the upper jaws.

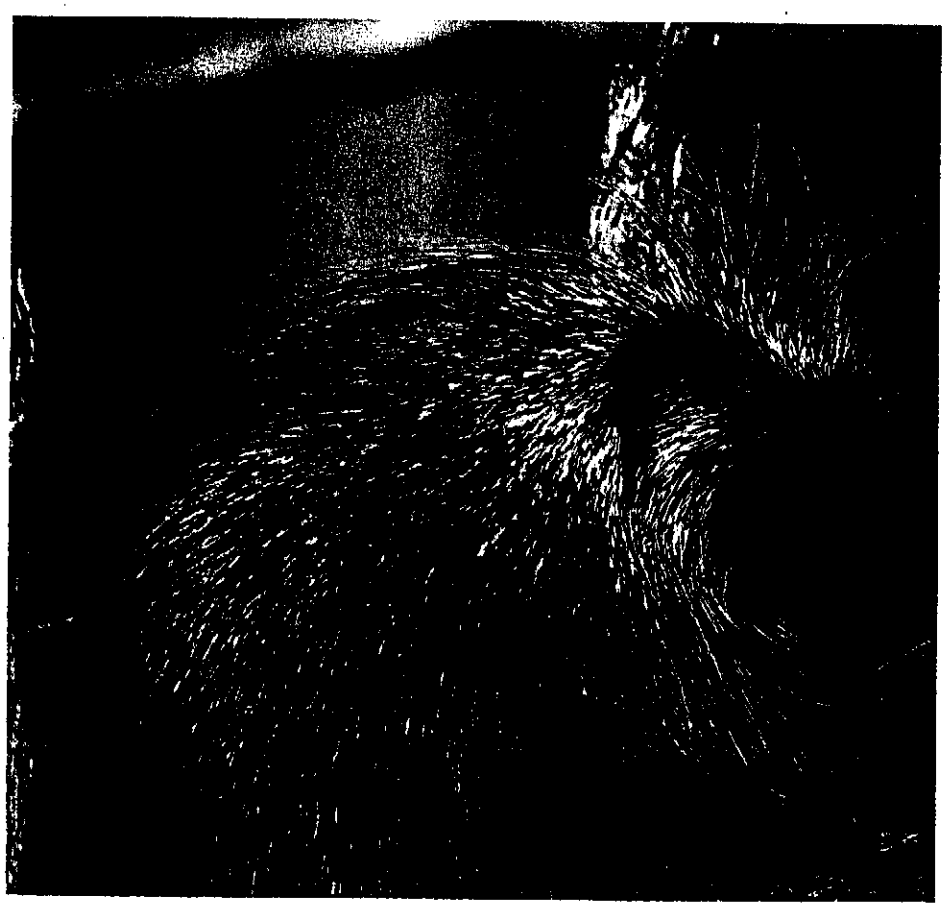
Gray fox

Tim Fuller

Animals which are more widespread in the mesic mountain forests or tropical woodlands but which are restricted to riparian habitats in the desert include raccoons and coatis. In the lower Colorado River valley subdivision of the Sonoran Desert, conditions became so hot and dry that typical desert creatures are concentrated in the dry washes which offer a little more moisture and vegetation than the surrounding desert. These animals include the desert spadefoot toad, red-spotted toad, Sonoran Desert toad, and side-blotched lizard.

Loss of Biodiversity

The list of animals which are riparian obligates or associates could go on and on. In terms of species diversity, productivity, and numbers of individuals, the Southwest's riparian areas are its most valuable wildlife habitat. They are fast disappearing. One wonders how many species have vanished — or are vanishing — along with them. Because riparian areas were impacted before their wildlife could be carefully censused, we have no



Porcupine

Although the porcupine is widespread at higher elevations, in the desert it is found primarily in riparian areas, where it is fairly common. In fall and winter, it feeds on the bark of trees, but switches its diet to forbs in the spring and summer.

base data against which to compare current populations. However, we do know some details which may suggest the larger story. In *Once a River*, a study of the middle Gila River, Amadeo Rea calculates that 25 bird species directly associated with riparian woodlands or open water have been extirpated and at least another 25 species have conspicuously declined in numbers. Several mammal species which were once found in Arizona's riparian bosques are now gone completely — grizzly bears, gray wolves, jaguars, ocelots, probably the otter — and others, like the beaver, have declined as their habitat has dwindled. Nine species of herpetozoans included in the Arizona Game and Fish Department's Proposed List of Threatened Wildlife in Arizona (1987) are clearly riparian obligates and five others are strongly associated with, and probably dependent on, these habitats. Together, these comprise nearly 61% of the reptiles and amphibians

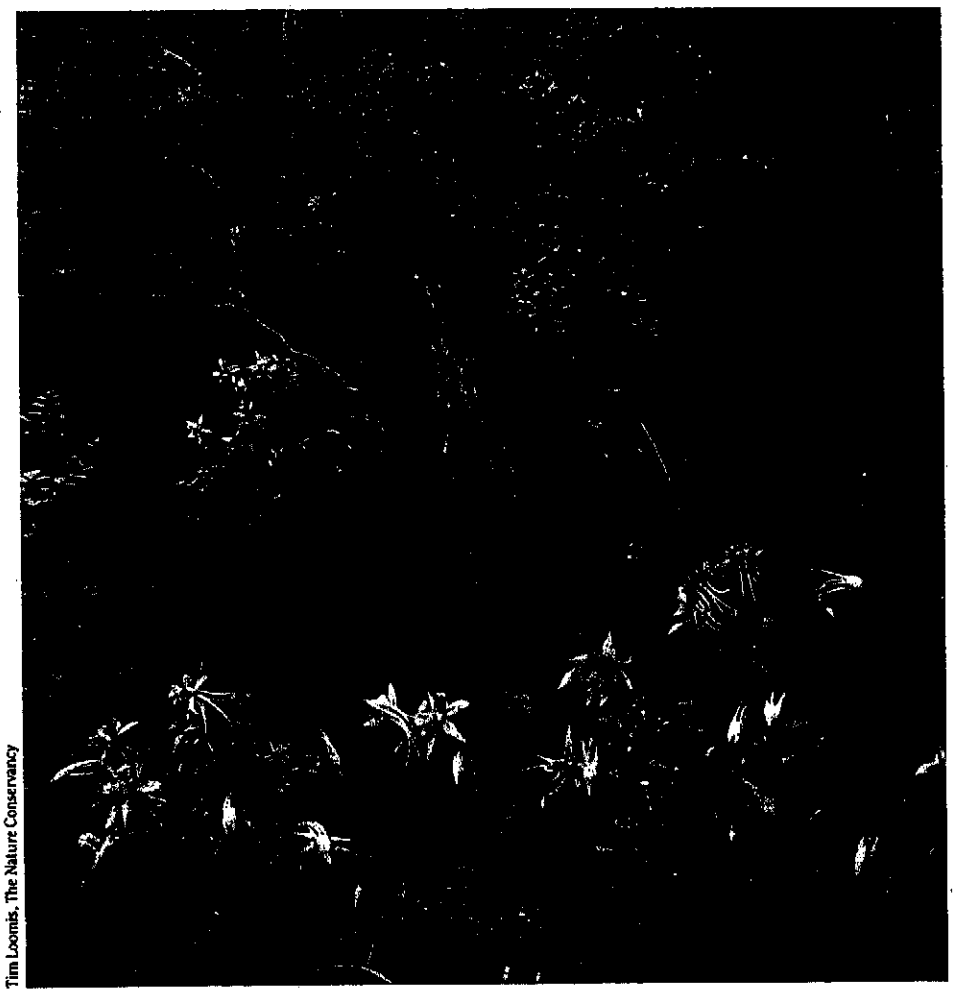
Howard Lawler

Lowland leopard frog

thought to be in need of special conservation management in Arizona. Most species are in jeopardy because of loss of habitat. A few have another story to tell as well.

The Tarahumara frog inhabits permanent streams in mountains associated with the great Sierra Madre Occidental of western Mexico. It occurs in considerable numbers where it is undisturbed, and was once common at the six known localities in the Pajarito and Santa Rita Mountains of Santa Cruz County, Arizona. In the late 1970's a mysterious and sharp crash occurred in these populations; today the species is considered extinct in Arizona. Some populations in northern Sonora have shown similar die-offs, although Mexican populations south of the borderlands appear to be doing well. What caused this fatal decline in so short a time is still unclear, but evidence points to pollution from trace minerals or acid rain, probably originating with sulfur dioxide emissions from U.S. and Mexican copper smelters in the region. The permeable skin of this, and all frogs, makes them particularly vulnerable to water and air pollution. They may be important biological indicators of environmental quality in aquatic/riparian systems.

The leopard frogs comprise a species complex formerly considered to be a single species, but now shown to be several distinctive species, sometimes occurring together without interbreeding. Each species is specifically adapted to a particular variation of riparian habitat even though the species differ little in general appearance. Five species of leopard frogs occur in Arizona and two more in Sonora. Two, the plains leopard frog and the relict leopard frog, are considered endangered in Arizona; the latter may already be extinct in the state and is federally listed as Endangered. Accelerated loss of wetland habitats and the introduction of the non-native bullfrog have sharply reduced populations of



Tim Loomis, The Nature Conservancy

Rare lemon lilies highlight the foreground in this scene captured at Ramsey Canyon Preserve.

C. Allan Morgan

Tarahumara frog

these formerly common frogs. Other leopard frogs are similarly threatened but to lesser degrees.

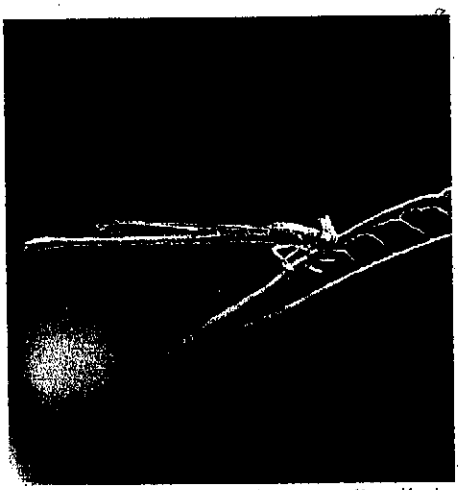
The bullfrog, a large, highly adaptable species, with a voracious appetite for anything that moves, is well established throughout most of southern Arizona where permanent water exists. It has been implicated in the decline or disappearance of populations of native frogs and other riparian vertebrates, such as the Mexican garter snake. A high percentage of these snakes at the San Bernardino National Wildlife Refuge east of Douglas have damaged or incomplete tails. Baby and juvenile garter snakes are abnormally scarce. The bullfrog is suspected to be responsible. Due to this predation and to habitat loss or degradation, several populations of this garter snake, whose U.S. distribution is almost entirely limited to southern and central Arizona, have been extirpated, and others are in decline.

In 1987, the Arizona Game and Fish Department rescinded bag limits and eliminated seasons on the taking of bullfrogs (except in counties along the Colorado River below Lake Mead) where they compete with and prey upon native wildlife. This will allow interested individuals, agencies, and organizations to put more pressure on the bullfrog.

Kevin Black

Regal Ringneck Snake

This snake enters sheltered, moist canyons to feed on other snakes, lizards, amphibians and invertebrates. It is mildly venomous, although the slightly enlarged rear teeth are not grooved. The bright reddish-orange ventral color serves a warning, or aposomatic, function. To deter a predator, the snake coils its tail like a corkscrew, waves it to attract attention, and hides its head beneath its coils.



Howard Lawler

Damselfly

Approximately 5% of insects spend all or part of their lives in the water. The majority of insect species occurring in riparian habitats are common outside the arid Southwest. Most of them have water-based reproductive cycles with aquatic nymph (naiad) stages and winged adult stages. Examples are the dragonflies and damselflies (Order Odonata); mayflies (Order Ephemeroptera), giant water bugs, water striders and backswimmers (Order Hemiptera) and the caddisflies (Order Trichoptera).

Howard Lawler

Sonoran Mud Turtle

Although turtles are usually associated with aquatic/riparian habitats, only two of Arizona's four native species are typically found in riparian zones. These are the Sonoran mud turtle, pictured here, which usually lives in upland habitats with flowing water, and the yellow mud turtle which occupies ponds and other standing water with muddy-sandy bottoms. Both are very aquatic and feed on invertebrates, amphibians, carrion and aquatic plants.

Jeanne Broome

Recently, the Pima County Flood Control District purchased nearly 2000 acres along Cienega Creek in southeastern Arizona. The protection of this creek helps mitigate impacts of flood control projects elsewhere in the county.

Benefits of Riparian Systems

Desert riparian areas are valuable chiefly because of their biological diversity. Their plant and animal diversity can help meet the medical, agricultural, or industrial needs of human beings; thus this diversity has both actual and potential economic value. However, its primary benefit to a healthy, functioning, evolving ecosystem cannot be calculated, nor can its restorative effect on human beings, who delight in variety, vigor, and surprise.

Other benefits of a riparian area can be quantified. Hunting, fishing, and trapping, which often occur in riparian areas, bring considerable revenue, both direct and indirect, to local economies. Perhaps even more important economically are the nonconsumptive uses of riparian areas (wildlife observation and photography, camping, picnicking, hiking, etc.) which contributed $114,000,000 to Arizona in 1970. In 1978, tourists visiting just three riparian areas in southern Arizona (Ramsey Canyon, Madera Canyon, and Cave Creek) spent over $5 million, or $12,370 per acre. Water-based recreation, such as river running, is becoming a multi-million dollar industry.

Riparian vegetation helps purify air, and its waters can clean a community's effluent, a service estimated to be equivalent to between $400 and $1,500 per acre per year. By controlling erosion and stabilizing banks, riparian vegetation can help prevent flooding. In fact, according to Army Corps of Engineers analysis, riparian plants save more money controlling floods than it would cost to remove them, a practice sometimes done for flood control. Other values of riparian systems range from groundwater recharge to honey production.

The Future

E. O. Wilson begins a recent book, *Biodiversity*, this way: "The diversity of life forms, so numerous that we have yet to identify most of them, is the greatest wonder of this planet." These wonders can come in small places: in a tidepool or beneath a rock. But certain habitats are especially rich: tropical rainforests, coral reefs, and wetlands, including riparian areas. These pages have barely suggested the complexity of lives to be found in Arizona's wet places. (We have not discussed invertebrates, yet they probably constitute the majority of life forms there and are fundamentally important to the functioning of the whole.) Protection of species diversity is one of humanity's major responsibilities, but it is one we take all too lightly. We have been reckless with our riparian areas, placing value on what could be extracted from them — water, timber, food — but seeing no benefit to the intact system — the greatest wonder of our planet. If we are to save the remaining 5% of our original riparian systems, we'll have to change our values. "Arresting the loss of diversity will be extremely difficult," comments biologist Paul R. Erlich. "A quasi-religious transformation leading to the appreciation of diversity for its own sake, apart from the obvious direct benefits to humanity, may be required to save other organisms and ourselves."

Many organizations and individuals are working to effect this transformation of values and to protect remaining riparian areas from ill-conceived development and improper uses. One of these is the Arizona Riparian Council, a two-year-old

organization with over 400 members which exists "to provide for the exchange and transmittal of information on the status, protection, and management of riparian systems in Arizona." Several other private organizations have helped protect the state's riparian areas by raising issues, lobbying for protection, and sometimes actually purchasing or rehabilitating riparian areas. These include the Desert Fishes Council, the Sierra Club, the Audubon Society, the Wildlife Federation, the Wilderness Society, Ducks Unlimited, Trout Unlimited, and The Arizona Nature Conservancy, which recently launched a three year campaign, "Streams of Life," to acquire or protect 19 of Arizona's remaining riparian areas. Public agencies are emphasizing the wetland and riparian habitats among their holdings. To mention only two, Arizona State Parks has identified certain natural areas and critical habitat most in need of protection; 93% of these are wetlands or riparian areas. The Bureau of Land Management has acquired some big riparian areas, including 30 miles of rare broadleaf riparian habitat on the San Pedro, and has begun to inventory all riparian areas on its lands.

Riparian systems are old. Whether they survive much longer depends on the actions of the upstart creature which has only recently cared enough about them to even name and define them. This creature, humankind, while famous for its shortsightedness, is also capable of imagination, vision and courageous action. These qualities are needed now. If we choose to use them, we may save not only Arizona's most valuable habitat, but the quality of our own lives as well. ■

Palm Oases: A Special Desert Riparian Habitat

Fifty million years ago the warm, wet climates of the early Tertiary supported tropical rainforest in what is now the Sonoran Desert. Fossil palms were found as far as 60° north in Alaska! Surprisingly, palms still occur in protected oases in this core desert even though July temperatures often rise to above 110°F and rainfall barely reaches three inches per year.

Two native palms are endemic to the Lower Colorado River Valley subdivision of the Sonoran Desert. Stands of the desert fan palm are found in over 60 springs, seeps, or desert streams from southern Nevada to western Arizona and northern Baja California. The thread palm is endemic to Baja California and a few islands in the Gulf of California. These palms are the Sonoran Desert's greatest contribution to ornamental horticulture.

The desert fan palm is the most massive palm native to North America, reaching a height of 76 feet and 40 inches in trunk diameter. The skirts of dead leaves hanging around their trunks have led local people to call them petticoat palms. Well-developed stands greatly modify these desert riparian habitats into verdant oases.

The water and shade of palm oases attract abundant wildlife including over 80 species of migratory birds. The trees' great height — the equivalent of a six- or seven-story building — can serve as distant signs attracting birds, coyotes, and bighorn sheep. Coyotes which visit all oases are probably the most important dispersal agents of the palm's seeds. Seeds that have passed through their digestive tracts germinate more successfully than unconsumed seeds. Coyotes are known to travel up to 36 miles in three days, enough to establish most of the known fan palm sites.

Desert fan palms in more isolated springs at Mopah Spring in California's Turtle Mountains and the Kofa Mountains and Castle Creek of western Arizona may have been established by humans. Native North Americans, who often lived in the oases, had many uses for the palms and were known to carry the seeds to new areas. They used the leaves to build huts and to weave baskets. They ate the fruit fresh or dried, made a flour out of the seeds, and roasted the terminal bud or "cabbage" to eat. As a mature fan palm can produce up to a half million pea-sized dates with a sweet-tasting flesh, this was a major food resource for desert dwellers.

Unlike the many other riparian habitats, fan palm oases appear to be in good condition. The trees are tolerant of fire and not adversely affected by most casual uses of the habitat. In fact researchers at the Palm Springs Desert Museum in California have recorded a 40% increase in the population of wild fan palms since 1945, primarily due to natural increases in rainfall and clearing of debris by fires. As long as the ground water feeding the springs is protected, these desert oases can be expected to survive.

Pushawalla Canyon, California

Mark Dimmitt

Suggested Readings on Riparian Ecosystems

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(continued)

Thanks to outgoing trustees

On behalf of the Museum's 17,000 members, the staff, volunteers and former colleagues we take this opportunity to thank the following whose four-year terms on the Board of Trustees ended in May: David D. Cohn; William B. Drew, Ph.D.; Robert W. Jones; Jean Russell; Patricia H. Waterfall; and Patricia A. Young. Thanks also to the other members of the 1987–88 Board of Trustees and Advisory Council who so skillfully guided the Desert Museum through another successful year:

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ASDM receives grants totalling $90,000

The Desert Museum has been successful in two grant applications. The Institute of Museum Services, a federal agency that offers general operating support to the nation's museums, awarded the ASDM a $75,000 General Operating Support grant beginning last June to implement a new member campaign and to analyze the current ASDM membership. This was the third IMS grant, and the second in three years, the Museum has been awarded.

Also last June, the Museum was advised that the Burlington Northern Foundation approved a grant in the amount of $15,000 to assist in the "Desert Discovery" project, a new program of the Museum's Education Department which will provide learning kits to Arizona school teachers to use in classes in desert ecology on the elementary level. The Burlington Northern Foundation represents the following Burlington Northern Inc. subsidiary companies:

BN Motor Carriers, Inc.
Burlington Northern Railroad Company
El Paso Natural Gas Company
Glacier Park Company
Meridian Minerals Company
Meridian Oil Inc.
Plum Creek Timber Company Inc.

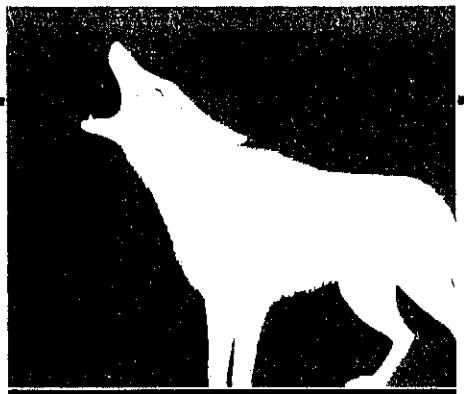
This is the second grant to the ASDM from Burlington Northern in three years.

Trip to Zimbabwe, Zambia, Botswana Filling Up

A number of commitments have been made for the Museum Foundation's trip to Africa in 1989 as a result of our announcement in the last issue of *sonorensis*. Since the announcement, dates have been firmed for this fabulous 22 day, never-to-be forgotten adventure to mysterious Africa. Mark September 10 through October 2, 1989, on your calendar.

You are invited to camp with us on the banks of the Zambezi, visit the Kalahari, explore the Okavango Delta in a dugout canoe surrounded by magnificent birdlife, and stand in awe of Victoria Falls. You'll view the wildlife from safari vehicles and on foot with armed professional guides in some of the really great national parks of Africa such as Hwange (Zimbabwe), Luangwa (Zambia) and others.

This trip is limited to 15 people, so reservations should be made as soon as possible to assure yourself a slot. Contact ASDM Director Dan Davis or Administrative Secretary Jean Morgan at (602) 883-1380 for information.



SPECIAL EVENTS

Barranca del Cobre by Train and Trail

An 8-day expedition in to Mexico's Sierra Madre
Thursday–Thursday
September 29–October 6, 1988

Carved and sculpted deep into the high Sierra Madre Occidental of Mexico is a network of precipitous canyons so forbidding and remote that modern transportation has penetrated them only in recent years. This is Mexico's Barranca del Cobre or Copper Canyon, every bit as majestic as the Grand Canyon. Here, human history is telescoped, and high-tech culture reaches out and touches hands with cave-dwelling Indians. It is the land of the Tarahumara, a durable, self-sufficient people known for their ability to run for great distances at high altitudes without fatiguing.

The trip originates in Los Mochis, Sinaloa where we will spend a leisurely day at nearby Topolabampo Bay aboard a yacht, watching blue-footed boobies and possibly black skimmers. Early the next morning we begin the most incredible train ride ever engineered, carrying us from the coastal thorn scrub through tropical short-tree forest. The terrain is accented by fluffy kapok trees and strangler figs. Finally, we'll reach the Madrean oak and conifer forest reminiscent of the mountain islands we know in Southern Arizona. Accompanied by Museum naturalists, we'll take bird walks, embark on interesting plant explorations and share vistas of the fabulous volcanic geology that formed this breathtaking landscape. We will reach a new awareness of how the Sonoran Desert came to be. There will also be time to shop for unique Tarahumara basketry, musical instruments, pine bark dolls and other handcrafts.

All accommodations are in beautiful but often remote and primitive quarters. As always in Mexico, be prepared for bouncy roads, long waits, bustling boardings, and warm smiles from wonderful people.

Questions? Call Mary Erickson at 883-1380, ext. 205

Trip fee of $825 (non-members $865) includes all accommodations, all meals, first class train tickets and all transfers beginning and ending in Los Mochis. Not included is the round trip flight from Tucson to Los Mochis (currently $172). We will be happy to assist with travel arrangements.

Registration and Reservation Information: Registrations are accepted by mail or in person only and are processed in the order they are received. Please fill out the form below and mail it with your trip deposit of $100 per person. Balance of payment is due 35 days before departure.

Refunds and Cancellations: Deposit is refundable in full until time of final payment. A $100.00 per person charge will be assessed for cancellations 35 to 14 days before departure. No refunds will be made 14 days prior to departure. Cancellation insurance is available at extra charge.

*This itinerary is predicated on published airline and train schedules, but delays are always possible. Tour rates are those in effect at time of printing. Any changes in transportation, hotel or currency exchange rates will be reflected in the final tour price. Rates are per person and double occupancy.

Please list below name, address and phone number for all participants (attach list if necessary)

Send check payable to Arizona-Sonora Desert Museum to: ASDM Members' Special Events Office, 2021 N. Kinney Road, Tucson, AZ 85743

Participant 1 _____

Address _____

City _____ State _____ Zip _____

Membership number _____

Phone: Home _____ Work _____

Participant 2 _____

Address _____

City _____ State _____ Zip _____

Membership number _____

Phone: Home _____ Work _____

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The Desert Museum needs to continue to increase its membership. And we're asking you to help. Furthermore, for your trouble here's an offer that's hard to beat:

For every membership you purchase as a gift, or for every new membership referred by you, the Desert Museum will *give you* as many Guest Passes as come with that new membership.

This offer is for ASDM members only. To be assured proper credit, your name must also appear on the new member's application.

Thanks for your help.

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