Sonorensis

Arizona-Sonora Desert Museum

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60 YEARS
of Science & Conservation

2012

Sonorensis
Arizona-Sonora Desert Museum

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The Arizona-Sonora Desert Museum
Co-founded in 1952 by
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Sonorensis is published as a benefit to the Arizona-Sonora Desert Museum membership. It is intended to further our members' understanding of the Sonoran Desert Region and shape their sense of stewardship.

Visit us at www.desertmuseum.org

Cover: White-lined spinx moth *(Hyles lineata).* Sari ONeal.

Back cover: Common Thistle *(Cirsium vulgare).*

Thanks to all the photographers and organizations who contributed photos for this issue of Sonorensis.


Steve Millspaugh


Rhonda Spencer


Mark Dimmitt

A Retrospective

Introduction

Richard C. Brusca, Ph.D.
ASDM Director Emeritus


ASDM


EDI


Jesús M. García


Mark Dimmitt


K. Cliffton


Rick Brusca

Left to right: Terns, Isla Rasa Island. Night-blooming cereus. Peach tree in Canyon de Chelly. Buffelgrass. Leatherback hatchlings. Seafood market in Mexico.

CONTENTS

Since the Desert Museum first opened its doors 60 years ago, it has worked to understand and protect the Sonoran Desert Region. In fact, the Museum's exhibits and programs largely derive from the research of its staff. Although a formal "Conservation and Science" department wasn't named until 1995, curators, educators, and administrators had undertaken conservation work for many decades. From the outset, the Sea of Cortez was recognized as a fundamental component of the Sonoran Desert Ecoregion, and one of the Museum's first big conservation achievements was the establishment of Isla Rasa Protected Area in 1964, the first conservation reserve ever established in Mexico. This and other notable stories are told in this 60th Anniversary retrospective issue of Sonorensis.

The Museum also played a key role in its support of Pima County's award-winning Sonoran Desert Conservation Plan. The science-based public television series that the Museum launched more than 20 years ago is still on air—The Desert Speaks. The Desert Museum's many books and magazines on Sonoran Desert natural history have enriched the lives of millions of readers, and its technical book series, ASDM Studies in Natural History, has produced an on-going baseline of science for the region, focusing on topics as varied as invasive species, migratory pollinators, the desert tortoise, and the Sea of Cortez. And, the Desert Museum's work with Nature and Culture International (a California non-profit) and Mexico's National Park Service (CONANP) led to the establishment of a reserve near the colonial town of Alamos, Sonora, protecting one of the last intact Tropical Deciduous Forests left in Mexico.

In this special issue of Sonorensis, the Museum looks back at some of the conservation themes it has embraced in past decades, along with updates to those themes from current science staff. Peggy Larson—the Museum's librarian and archivist, and wife of former Executive Director Merv Larson—tells the Isla Rasa story. An introduction to packrat middens is provided by one of the pioneers of Southwestern paleoecology, former ASDM researcher Tom Van Devender. Former Director of Collections, Peter Siminski describes some of the Museum's signature endangered species recovery programs in the 1980s, including the Mexican gray wolf initiative. The gray wolf recovery program was launched by the Museum in the 1950s, and by the time the wolf was listed as Endangered, the U.S. Fish and Wildlife Service was able to use the Museum's wolf gene pool to launch their own recovery program throughout the Southwest.

Former Director of Natural History, Mark Dimmitt, reminds us that endangered plants have been part of the Museum's research as well. Former Museum Science Director Gary Nabhan describes the special mutualism between the famous "Desert Queen-of-the-Night" cacti and their pollinating hawk moths. Around the time this article first appeared, the Museum launched a migratory pollinator project that has continued to this day. And Dr. Nabhan's article on exotic invasive plants reads like a harbinger—today the Sonoran Desert is literally being overrun by African buffelgrass and other invasives. Nowadays, it is widely recognized that invasive species are second only to outright habitat destruction in their ability to destroy natural biological communities. Tucsonans need only look to the north, at the slopes of the Santa Catalina Mountains, to see the spreading yellow patches of buffelgrass that threaten to destroy our beautiful saguaro-palo verde forests. The Museum was instrumental in establishing the Southern Arizona Buffelgrass Coordination Center to address this ongoing threat.

In 2007, the Museum launched its "Kino Heritage Fruit Trees" project. The project, founded by Rick Brusca and Robert Emannuel, and later spearheaded by Education Specialist Jesús Garcia, partners with the National Park Service and Desert Survivors Nursery (in Tucson) to track down original colonial era fruit tree stock brought to the Pimería Alta region by Padre Kino and his colleagues to propagate and revive the varieties.

Two articles near the end of this commemorative issue return to the Sea of Cortez. The "long arm" of the Sea of Cortez even reaches Tucson, and much of the Southwest, in the form of summer monsoons. Once thought to originate in the Gulf of Mexico, we now know that almost all of the summer monsoon rain comes from the Gulf of California/Tropical Eastern Pacific, often in masses of water-laden air called "Gulf Surges" that rush right up the middle of the Sea of Cortez to dump their harvested moisture in southeastern Arizona and adjacent areas.

Sea turtles have long been threatened, although all six species are now protected in both the U.S. and Mexico. Executive Director Craig Ivanyi's 2002 article on these "desert ocean jewels" recaps struggles to save these beautiful creatures. The final article, on seafoods and marine fishing in the Sea of Cortez, helped launch the Museum's partnership with Monterey Bay Aquarium to publish a Seafood Watch Pocket Guide for the Southwest (where much of the market and restaurant seafood comes from the Gulf of California).

Taken together, the articles in this issue of Sonorensis give the reader a broad peek into the scope and depth of the Desert Museum's conservation work over the past 60 years. An important and valued component of the Museum's overall mission, science and conservation efforts at ASDM will no doubt continue to provide important contributions to our beloved Sonoran Desert. S

Above left: Heerman's Gulls lounging on rocks. Above: The small boat that took Lew Walker to Isla Rasa on his first visit in 1946. Cut out below: Baby Heerman's Gull.

Above: Young Heerman's Gull. Above middle: Lew Walker with background of Isla Rasa, the major nesting area for both Royal and Elegant Terns, thousands of which migrate there to breed each spring. Above right: Young Heerman's Gull. Cut out below: Young Tern begging for food.

SAVING THE BIRDS OF ISLA RASA

How One Man Began a Movement to Protect Waterfowl

Peggy Larson
ASDM Librarian and Archivist

One of the world's densest avian nesting populations, located approximately 400 miles south of the head of the Sea of Cortez, would have been irreparably lost in the 1960s if not for a small group of U.S. and Mexican conservationists, one concerned benefactor, and the President of Mexico. The man who brought these people together was Lewis Wayne Walker, ornithologist, photographer, author, and Associate Director of the Arizona-Sonora Desert Museum from 1954 through 1970.

Isla Rasa is less than a square mile in extent and at its highest point not quite 100 feet above sea level, yet it is the primary nesting area for both Royal and Elegant Terns, and the main breeding location for the Heermann's Gull. It is estimated that Gulf of California islands, primarily Isla Rasa, provide nesting habitat for 90 percent of the North American populations of these three species.

Lewis Walker began exploring Baja California and the Sea of Cortez in the late 1930s. At that time, roads in Baja were dirt tracks and the waters of the Gulf little known except by Mexican fishermen. He first visited Isla Rasa in 1946. The masses of birds Walker found on Isla Rasa thrilled him, and upon his return to the U.S. he sold an article and photographs, "Sea Birds of Isla Rasa," to National Geographic. In 1947 he returned to the island, but to his amazement found very few nesting birds. Their absence was a puzzle, but Walker found an ominous clue: "Human footprints were plainly evident where they had not been erased by the winds."

The footprints were later explained when Walker met a Mexican fisherman who reported that motorboats had visited Isla Rasa earlier that year and removed thousands of eggs to be sold for food in Santa Rosalía and other ports. There had been some minor egg harvesting in other years, but as transportation became easier and markets grew, the eggers had increased in number.

As Walker returned to Isla Rasa year after year he documented the astounding decrease in the bird population. There were years when reproduction, which should have been close to a million, was cut to several thousand. It seemed that Isla Rasa's days were numbered.

Walker shifted into high gear. Dr. Joseph Wood Krutch, a Desert Museum Trustee, was a good friend of Walker's, and Krutch in turn had been in correspondence with a San Francisco industrialist and Board member of the California Academy of Sciences, Kenneth Bechtel. When Bechtel heard Walker's story, he took Krutch, Walker, Arizona-Sonora Desert Museum Director William H. Woodin, and others by plane to Baja California, where the group began to study the need for research and conservation. They returned numerous times, and Bechtel established the Belvedere Scientific Fund with Krutch, Walker, Woodin, and other well-known scientists named to the board.

Meanwhile, Walker sought the help of several high-profile scientists of the day, including Roger Tory Peterson, renowned ornithologist, author, artist, and an administrator with the National Audubon Society, Dr. George Lindsay of the California Academy of Sciences, and Carl Buchheister, President of the National Audubon Society. In 1961 Peterson, Krutch, Walker, and Mervin Larson from ASDM spent a week on the island producing a film, which they distributed widely.

They further brought the desperate need for protection of the birds of Isla Rasa to the attention of Mexican scientists. Dr. Enrique Beltran, Mexican Subsecretary of Forestry and Game, and Dr. Rodolfo Hernandez Corzo, Director General of Wildlife, became personally and professionally involved in the project. At last, on May 30, 1964, President Lopez Mateos signed a decree which named Isla Rasa a Migratory Waterfowl Reserve, a move that ultimately led President Jose Lopez Portillo to decree in August 1974 that all of the Gulf islands were to have similar protection, their plants and animals to remain undisturbed. The resulting reserve is the "Islas del Golfo de California Area de Proteccion de Flora y Fauna."

Today Isla Rasa is accessible only to researchers. On the island, the Heermann's Gulls and terns are flourishing. Egg collecting has stopped and scientific knowledge regarding the birds has greatly increased. With assistance from the Universidad Nacional Autonoma de Mexico, two rodent species, black rats and house mice have been eradicated from the island, resulting in an increase in the breeding success of the birds.

Certainly Lew Walker's early efforts to save the birds of Isla Rasa have borne rich rewards for the Gulf islands. After his death in 1971, Lew's wife, Melanie, stated, "Lew's proudest achievement was the role he played in the creation of this sanctuary." In accord with Lew's wishes, his ashes were scattered over Isla Rasa.

UPDATE

The Sea of Cortez remains one of the most pristine and biodiverse marine regions in the world. Contemporary conservation efforts aim to enable that biodiversity to persevere into the future. Thousands of species depend on the Gulf region, which faces increasing disturbance and environmental change. Current challenges of the Gulf region include overfishing, industrial shrimp trawling, and development of sensitive coastal regions.

Targeting coastal conservation, efforts by Mexican organizations have initiated restoration of islands in the Sea of Cortez. One of the key elements of these efforts has been removal of non-native species on islands, allowing protection and recovery of nesting seabirds and endemic plants and animals. ASDM researchers are working with Mexican partner nonprofits and government agencies to support and extend their efforts and to assist with the recovery of sensitive island ecosystems. S

Clare Aslan, Ph.D.
ASDM Conservation Research Scientist

Paul Bicquiet

Commonly called packrat, white-throated woodrat *(Neotoma albigula)*

Our FIRST CURATORS

Thomas Van Devender, Ph.D.
ASDM Senior Research Scientist
1983-2009

Paleontologists
have long fascinated us
with reconstructions of ancient life on earth.
We have all seen fossil skeletons and drawings
of the bizarre beasts which roamed
the earth millions of years ago and
we have wondered what
it must have been like then.
Exciting new innovations are providing
paleoecologists with data which give us
a remarkably accurate picture of
the ancient Sonoran Desert area.
For much of the new information we are
*indebted to Neotoma—**the pesky packrat.***

PACKRAT MIDDENS AND EXPLORATION OF THE WEST

In the 1849 Gold Rush a group of emigrants crossed the inhospitable Mohave Desert from Utah to California on a journey that nearly ended in disaster in Death Valley. Desperate for food and water they:

> *"Came to a high cliff and in its face were niches or cavities, and in some of them we found balls of a glistening substance looking like pieces of variegated candy stuck together. It was evidently food of some sort, and we found it sweet but sickish, and those who were so hungary [sic] as to break up one of the balls and divide it among the others, making a good meal of it, were a little troubled with nausea afterwards."*
>
> —William Many in 1894

This appears to be one of the earliest accounts of the dark, shiny organic masses of plant debris and fecal pellets cemented together with urine that we know now as packrat middens. A little indigestion was not surprising!

PACKRAT NATURAL HISTORY

Packrats of western lore and legend are notorious for their remarkable habit of collecting samples of anything movable within their territory. Such items, usually vegetation, are brought to the den and incorporated into their houses. However, packrats also gather rocks, animal bones, insect parts, or anything small and interesting. Pioneers, cowboys, miners, and other frontiersmen invariably blamed the packrat for any missing valuables.

Packrats, or woodrats, are rodents in the family Cricetidae. They belong to *Neotoma*, a New World genus whose fossil history goes back about three to four million years. Today there are about 20 species widely distributed in many habitats in North and Middle America. Only the white-throated packrat and the desert packrat live in the Sonoran Desert.

The packrat's gathering and hoarding nature, and the fact that they live in arid, often rocky environments, have made them and their remains a valuable scientific tool. Ancient packrats of the dry deserts of North America have provided today's scientists with a figurative window to the past. Like their modern counterparts, packrats of thousands of years ago gathered plant materials from their immediate surroundings. Based on modern behavioral studies, we know that packrats ordinarily do not venture more than 300 feet from the protection of their houses—and most of their activity is within 100 feet. On their gathering forays, packrats select such things as twigs, leaves, seeds, fruits, and cactus joints for food and to enlarge and fortify their houses. Houses protect the rat from predators and from temperature extremes. Near the entrances are waste piles, called middens, where fecal pellets and unwanted materials accumulate and are consolidated through trampling and the addition of urine. The oldest packrat midden found to date was more than 50,400 years in age.

In order to study the contents of packrat middens, they are dissolved in water, allowing the plant fragments to be screened out. After drying, myriad plant fragments are carefully removed from the matrix. Bones and insect remains are less common, but regularly found. Some of the more unusual objects found in ancient middens include pottery and twine (1200 years old), chips of mammoth teeth (19,000 years old), shark teeth (65-75 million years old), and fossil crinoid stems (several hundred million years old).

Occasionally middens from the northern Chihuahuan Desert have more than 50 kinds of plants per sample. Sonoran Desert assemblages usually have about 15-25 species. Thus, each packrat midden provides a mini-herbarium of the local flora at a point in time. Series of middens from one area can provide a historical chronicle of the vegetation in that area.

WOODLANDS IN THE DESERT

When I entered graduate school at the University of Arizona in 1968, the Ice Age vegetation of the Sonoran Desert was unknown. In a course entitled "Paleoecology and Man," Paul S. Martin presented packrat midden analysis as an exciting new source of well-preserved perishable plant remains from the deserts themselves. Thanks to this method, today we know quite a bit about the Ice Age vegetation of the Sonoran Desert. Taken together, the plant macrofossil assemblages from middens and their radiocarbon dates provide a reasonable outline of the last 30,000 years. Prior to about 11,000 years ago, a woodland with single-needle pinyon expanded down to about 2000 feet in elevation. (Today the lower limit of this woodland is at about 4000 feet.) Most of the lower elevations supported a drier woodland with California juniper and sometimes shrub live oak mixed with desert plants. Below about 800 feet, desert scrub vegetation, dominated by creosote bush and white bursage, probably weathered the Ice Ages relatively unaltered. Today this community dominates lowland valley bottoms in most of the Mohave and Sonoran Deserts.

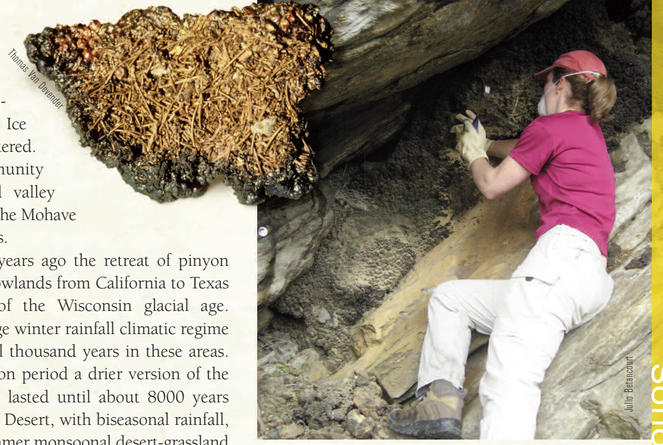
About 11,000 years ago the retreat of pinyon pines from desert lowlands from California to Texas marked the end of the Wisconsin glacial age. However, the Ice Age winter rainfall climatic regime persisted for several thousand years in these areas. During this transition period a drier version of the Ice Age woodlands lasted until about 8000 years ago. In the Sonoran Desert, with biseasonal rainfall, an intermediate summer monsoonal desert-grassland probably delayed the final modernization of the deserts until only 4000-5000 years ago.

As post-glacial climates warmed, summer rainfall increased and the Sonoran plants began to disperse northward, each at its own pace. Saguaros reached Arizona by about 9000 years ago while foothills palo verde only arrived about 4000 years ago. The formation of the rich palo verde-saguaro community of the Arizona Upland did not happen until all of the principal actors made it to the stage—in this case, the Tucson Mountains, the home of the Desert Museum.

UPDATE

Understanding climates of the deep past relies on deciphering evidence left in "climate proxies" such as packrat middens, tree rings, lake sediments, cave deposits and a host of other natural environmental records. Today, climate is still changing, but even faster than before due to the warming effect of greenhouse gas emissions. No "proxies" are needed to record this modern day climate change. In addition to temperature and precipitation measurements which show a warming, drying Sonoran Desert, scientists (including citizen scientists!) have observed bird species north of their historical ranges, plant communities shifting higher in elevation, decreasing surface water in springs and streams, and earlier blooming of many plants. Climate models predict that the Southwest US will warm more than the rest of the country, although predictions of future precipitation are less certain. The impact of changing climate on ecosystem interactions and sky islands in the Sonoran Desert will be a major focus of future research at ASDM. S

Debra Colodner
Director of Conservation Education & Science



Thomas Van Devender

Julie Betancourt

Cut previous page: Commonly called packrat, white-throated woodrat *(Neotoma albigula)*. Cut out above: Ancient packrat middens are a source of well preserved fossils from the deserts. Note pine needles and juniper twigs in this 14,000 year old sample from a palo verde-saguaro area in western Arizona. Above: Found near a rock ledge, this fossilized packrat midden is typical both for its location and appearance.

Sonorensis 1983

Rhonda Spencer

Endangered Species & ASDM RECOVERY PROGRAMS *Mammals and Birds*

Peter Siminski
ASDM Director of Collections1983-2003

MEXICAN GRAY WOLF

The Arizona-Sonora Desert Museum (ASDM) has been involved with the Mexican wolf since 1954. At that early date in ASDM's history, it was already rare. Yet, a $75 bounty was still paid for the carcass of any wolf taken in Arizona. ASDM received a male "killer wolf," as it was characterized in the Arizona Daily Star on June 4, 1959, from two cowboys that worked on a ranch near Tumacacori. Then, in 1961, a female pup was donated to the museum that was born in Sonora. With this pair, the Desert Museum began breeding in captivity.

In 1976, the Mexican wolf was listed as Endangered under the Endangered Species Act of 1973. In the late 70's, ASDM and the USFWS (US Fish and Wildlife Service) worked together to prevent the extinction of this endangered subspecies of the gray wolf. The USFWS captured some of the few remaining Mexican wolves in Mexico to form the nucleus of a captive breeding program for eventual re-establishment in the southwestern U.S. The Museum was the primary acclimatization center for them and the first birth from these wild wolves occurred here. As the captive population increased, wolves were dispersed to other co-operating institutions.

The USFWS appointed a team of wolf experts, including a member of the ASDM staff, to develop a recovery plan for the Mexican wolf, based on re-establishment in the wild of wolves from captive raised stock. It was finally approved in 1982. As the captive population grew, management logistics grew concurrently. The USFWS allocated the responsibilities and duties for the captive management of this critical population to a committee of zoo holders. The Desert Museum participates in this committee and maintains the internationally-approved Mexican Wolf Studbook.

The recovery of this complicated animal is proceeding according to plan. If re-establishment in the wild is ever achieved, it could be the most daring and noteworthy endangered species conservation effort in the U.S.

Far left: Ocelot *(Leopardus pardalis).*

Right: Thick-billed parrots *(Rhynchopsitta pachyrhyncha)* nesting in aspen cavity.

Steve Milpacher

ENDANGERED CATS

In addition, ASDM recently produced the initial draft of a recovery plan for the endangered cats of Arizona and Texas for USFWS. Although the plan primarily addresses the status and potential for recovery of the ocelot and the jaguarundi, the status of the margay and jaguar in the U.S. is also addressed. ASDM has always been a leader in the captive production of these endangered animals for educational display by other zoological institutions, acquiring in the process behavioral information about these secretive cats that has been useful to endangered species biologists in the field.

THICK-BILLED PARROT

A victim of habitat destruction in Mexico, the Desert Museum began raising the Endangered thick-billed parrot in captivity in 1967. In 1986, the Arizona Game and Fish Department (AZGFD) initiated the experimental release of these birds within their historic range, the Chiricahua Mountains. In conjunction with other zoos, ASDM is developing captive rearing techniques and producing young birds for the re-establishment effort. In 1986, two pairs of the museum's thickbills laid eggs.

BROWN PELICAN

ASDM also assists the AZGFD with the rehabilitation of Endangered brown pelicans that have been blown into the desert from their coastal homes. Every year a few pelicans are found hungry, weak, and dehydrated in the deserts of southern Arizona. AZGFD wildlife officers and individuals often bring these birds to the museum for care, until they are ready to go back to the sea. The AZGFD then ships them to Sea World in San Diego where they are released.

UPDATE

Today, the Museum exhibits Mexican gray wolves, an ocelot, thick-billed parrots and a brown pelican. In doing so, the Museum cooperates with breeding programs and supports recovery efforts. As of February 2012, there were 58 Mexican gray wolves living in eastern Arizona and western New Mexico as a result of reintroductions. Researchers are studying ocelots in Texas, jaguars in Sonora, Mexico and surveying for all those wild cats along the Mexico-US border. Unfortunately, thick-billed parrot reintroductions in the mid-1980s were unsuccessful, due to the impact of wild predators on the released parrots. On the other hand, brown pelicans are successfully recovered and were removed from the federal endangered species list in 2009!

In recent years, the Desert Museum has turned its focus to the conservation needs of rare reptiles, frogs and fish. The Herpetology, Ichthyology and Invertebrate Zoology Department works with government biologists on a multitude of conservation programs. Landmark propagation of the endangered San Esteban Chuckwalla has produced hundreds of these lizards over the years. In 2004, the first Tarahumara frogs were returned to the wild after being absent from Arizona for more than 20 years. In response to the huge Horseshoe Two Fire in 2010, the Museum has been holding and breeding native Arizona fish from the burn areas. Museum staff is engaged in important conservation programs for Chiricahua leopard frogs, Yaqui catfish, Sonora Chub and Mexican gartersnakes as well. At the time this update was written, there were nine Quitobaquito mud turtle eggs in the Museum's incubator. These would be among the first ones to be produced in captivity ever! S

George Carpenter & Stéphane Poulin
ASDM Chief Curators


Ben Williams


Glen Tepke.


Rhonda Spencer

Top right: Jaguarundi *(Herpailurus yaguarondi)*.
Middle right: Brown Pelican *(Pelecanus occidentalis)*.
Bottom right: Mexican gray wolf *(Canis lupus)*.


Mark Dimmitt

ASDM'S *Rare Plant Programs*

Mark Dimmitt, Ph.D.
ASDM Director of Natural History 1979-2011

The museum is significantly involved in the recovery efforts of two very rare plants. One is the Tumamoc Globe-berry. In 1985 less than a thousand plants were known, almost all in the vicinity of the Tucson Mountains, the location of the Desert Museum. It is interesting to note that although we are surrounded by this plant, none occur naturally on the museum grounds. Nearly half of these plants were in the path of the Central Arizona Project (CAP). If the species had already been officially listed as Federally Endangered, the Endangered Species Act may have required the route to be changed.

Although it was not yet listed, the Bureau of Reclamation (which is building CAP) agreed to carry out mitigation measures to reduce the impact on this rare species. It transplanted the tuberous roots of several hundred Globe-berries to safe ground. In case the transplants failed, the bureau contracted with the Desert Museum to propagate 2000 of the plants as a backup. Our population is a substantial portion of the known wild population, so this is a significant conservation effort.

The Tumamoc Globe-berry was listed as Endangered in 1986. Surveys conducted by the U.S. Fish and Wildlife Service have found plants in outlying areas around the Tucson Mountains. Several thousand plants are now known in locations ranging from the Tohono O'odham Reservation to southern Sonora. It is a very inconspicuous plant which is seldom noticed unless specially sought, and may not be as rare as was initially believed. It probably does, however, warrant some form of protection to prevent its future endangerment.

Additional plant projects involve *Amsonia kearneyana*. This member of the Dogbane family (oleander, natal plum, karoo rose, Madagascar periwinkle, pachypodium) is a small herbaceous perennial about two feet tall. It has been sought intensively and has not been found outside the single canyon in the Baboquivari Mountains where it was originally discovered. In the last five years the number of plants has declined from about thirty to only seven, for unknown reasons. Furthermore, only one of the surviving plants has successfully produced seeds in the last few years.

The U.S. Fish and Wildlife Service contracted with the Desert Museum to become involved in the recovery plan for this species. The museum currently has in its nursery more than forty amsonias, several times the known wild population. These plants will be used to produce seed, and the resulting seedlings will be planted in the wild to attempt to increase the population. In case that fails, ASDM will also attempt to establish a captive population.

THE NEED FOR *IN SITU* CONSERVATION

Due to space limitations, ASDM and other botanical gardens are unable to carry out large scale conservation projects on their sites alone. The preservation of species in captivity/cultivation is only a last ditch effort. Conservation of species in the wild and in their natural ecosystems is the only feasible way to maintain the world's diversity of life. Even if it were possible to maintain everything in greenhouses and cages, much would be lost,

Left: Kearney's bluestar *(Amsonia Kearneyana)*

Sonorensis 1987

because an ecosystem is much more than the sum of its species. Furthermore, captive populations change genetically, and much of their hereditary material is lost over time in the absence of natural selection. While ASDM's captive maintenance programs are valuable, the museum's greatest contribution to conservation is its educational effort to encourage conservation of the Sonoran Desert and other natural systems intact, *in situ*.

THE BOTANICAL PHARMACOPEIA

Why attempt to save endangered plants? The ethical/aesthetic premise is the most powerful, but is very difficult to promulgate in a world ruled by cold economics. It is ironic, then, that priorities for protection under the Endangered Species Act are determined mainly by aesthetic criteria. Birds and mammals have top priority, and the majority of the listed species are so-called "glamorous" animals which generate human affections. Many of them, such as the bald eagle, California condor, and San Joaquin kit fox are top carnivores that play very minor roles in their respective ecosystems. On the other hand, there are hundreds of species of mollusks in imminent danger of extinction, but virtually none are listed, or even well studied.

Despite economic arguments to determine the fate of species, there are nonetheless compelling economic reasons to keep the planetary diversity as high as possible. One type of plant-derived product which has had profound effects on the quality of human life is pharmaceuticals (drugs). Most medical drugs were originally discovered in plants (including fungi, e.g., penicillin, streptomycin, etc.). Although many of these are subsequently synthesized, 25% of our drugs still come from higher plants, and most of them would not have been discovered if the peculiar properties of the plants had not been observed by someone.

A popular garden plant, Madagascar periwinkle *(Catharanthus roseus)*, has saved the lives of thousands of cancer victims. It is the source of vincristine, which cures 50% of the victims of Hodgkin's disease, and is effective also against some forms of leukemia. Perhaps the rare amsonias, that are in the same family as the periwinkle, contain related drugs which will be effective against other cancers? We'll never know if these species become extinct.

Very few plants have been investigated for useful drugs, only about 5000 species. From these about fifty drugs have been discovered; these drugs are the basis of a six billion dollar industry (1980). If the same proportion (1%) of the world's one million plants contain valuable drugs, then there are about 10,000 drugs yet to be discovered. One might reasonably speculate that the cure or alleviation of most of our problems can be found somewhere in the plant kingdom.

Now consider that the above figures are only for drugs. Plants also yield foods, fuels, dyes, oils, fragrances, fibers, pesticides, garden flowers, and more. Every time we allow (or cause) a species to become extinct, we are foreclosing an option for our future.

UPDATE:

Listed as Endangered in 1986, the Tumamoc Globeberry was delisted 1993 (meaning it was removed from coverage by the Endangered Species Act). The wider range and number of plants became known with field work by a number of botanists, including the Research and Conservation staff of ASDM. Currently the plants do have several levels of protection. The US Forest Service status is Sensitive, Arizona Native Plant Law status is Salvage restricted – cannot be collected without a State permit, globally ranked as G3 – uncommon: there are 21 to 100 occurrences, rare over a wide range.

Kearney's Blue Star, *Amsonia kearneyana* was listed as an Endangered species by the United States Fish and Wildlife Service (USFWS) in 1989 and still maintains that protection. Surveys in the Baboquivari Mountains in the spring of 2012 revisited known populations in order to document the status and health of these plants. This site contained about 300 individual plants in 2011 and the 2012 survey monitored about 10% of these. Kearney's Blue Star can be seen growing in the Mountain Woodlands exhibit of ASDM.

Through a grant from the USFWS, ASDM's Botany Department has been able to raise the profile of threatened and endangered (T&E) plants. Display of T&E plants throughout the gardens,with signage indicating their status, may be found for most of the regional species. There are 16 listed plants in Arizona and half of those are found in the Sonoran Desert Region. S

George Montgomery
ASDM Curator of Botany

Madagascar periwinkle *(Catharanthus roseus)*

A MIDSUMMER NIGHT'S *Pollination*

Gary Paul Nabhan, Ph.D.
ASDM Director of Conservation and Science 1993-2000

White-lined sphinx moth *(Hyles lineata)*.

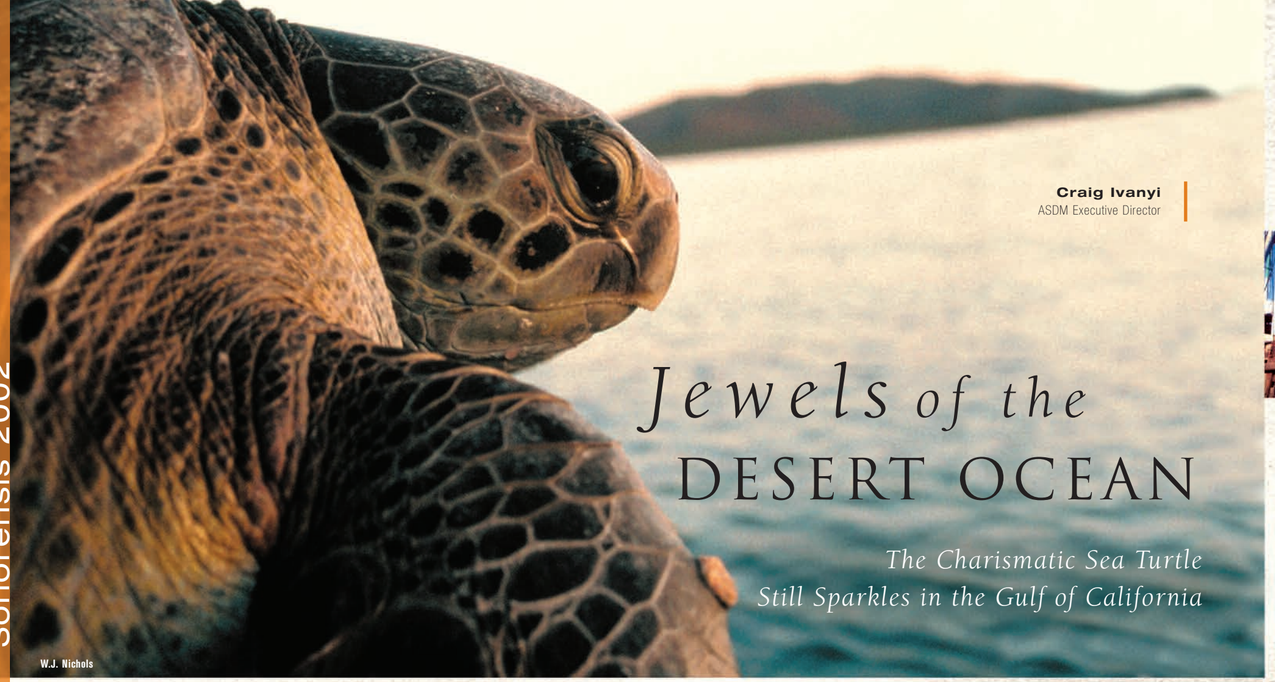
Of all night-blooming cacti in North American deserts, perhaps the least known is the dahlia-rooted cactus, *Peniocereus striatus*. Growing in the most sparsely populated reaches of southwest Arizona, coastal Sonora and Baja California, it is also among the least conspicuous of all Sonoran Desert cacti. Its lead-colored stems are pencil-thick and easily camouflaged amidst the gray branches of ironwood and creosote, its most common nurse plants. Biologists have walked within a few feet of them, without ever noticing their presence; their mimicry of desert shrubs is that effective.

That is, they are inconspicuous and well-camouflaged until they flower. Suddenly, it is as if brilliant white flashlights have been turned on under the desert shrubs, "flashlights" which also exude a musty but delicious, almost spicy, fragrance. For three summers running, I've had the good fortune of catching this rare night-bloomer and its pollinators "in the act." I've also had the misfortune of stumbling upon some previously-unrecognized threats to this species, threats which are locally disrupting the co-evolved mutualistic relationship between *Peniocereus* cacti and sphingid, or hawkmoths. These threats are insecticide spraying, nurse plant removal, overgrazing and vegetation conversion to exotic African pasture grasses planted as fodder for domestic cattle.

The *Peniocereus* has floral characteristics suggesting that it is adapted to visitation by hawkmoths. Typically, its flowers do not open until after the sun has gone down, so that afternoon-active bees do not rob its nectar and pollen. Its satiny-white floral tubes are 2-2.5 inches (8-10 cm) deep, perfect for hawkmoths such as *Manduca* species, which have tongues (proboscides) averaging 2 inches in length. With a little push past the pollen-saturated ring of stamens, even the shorter-tongued hawkmoths like *Hyles lineata* can reach the tube's hidden pools of nectar. At the same time, the hawkmoths get doused with enough pollen to carry to the next flower along the way. The *Peniocereus* positions its flowers at angles a little above horizontal, so that the hawkmoths can hover in front of the flower, or, less frequently, land on the lower petals and push their tongues into the deep floral nectaries.

Hawkmoths have structural and behavioral traits which make them well-suited to the task of carrying pollen from one cactus to distant neighbors, for the *Peniocereus* often occurs in densities of only 5-10 plants per acre. Because it is self-incompatible, this cactus must rely on strong-flying animals to move pollen in its widely-dispersed populations. My dye-tracking

Left: Close up of night blooming cereus *(Peniocereus striatus)*.



Jewels of the DESERT OCEAN

The Charismatic Sea Turtle Still Sparkles in the Gulf of California

Craig Ivanyi
ASDM Executive Director

Above: Pacific black sea turtle *(Chelonia mydas agassizii)*.

It was a warm October morning, and lying before me was my first sea turtle in the wild. I had often wondered what this event would be like. Though I had seen these majestic creatures in captivity, I had believed that an encounter in nature would be completely different – and it was. But, rather than being euphoric, it was a poignant moment. The black sea turtle lay dead at my feet. Green monofilament formed a plastic web that encased its charcoal-colored shell. Its eyes and other soft tissues had already become host to a series of invertebrate consumers and decomposers. The smell of death hung in the air. This animal was a victim of "incidental catch," wherein fishermen and shrimpers that choose not to use Turtle Exclusion Devices accidentally capture – and kill – a variety of sea turtles. Though I had read of such tragedies, witnessing it firsthand registered greater impact and wouldn't allow me the detached perspective that books make possible.

As truly aquatic beasts, sea turtles migrate great distances between nesting beaches and feeding grounds and have developed the ability to dive deep in the ocean, often staying underwater for prolonged periods. For example, though most recaptures of the olive ridley turtle (*Lepidochelys olivacea)* have been within 200 kilometers of their nesting beach, one turtle was recorded moving 1,900 kilometers in 23 days, with a speed of 82 kilometers per day against the current. The leatherback also travels great distances and has been discovered at depths greater than 1,000 meters.

In spite of their marine nature, sea turtles must lay eggs on land because their clutches of 50 to 200 eggs would suffocate under water. Many female sea turtles return to lay eggs on the very beach on which they hatched, and their abilities to find these places are legendary.

Upon emerging from the nest, hatchlings must quickly get to water to avoid a myriad of terrestrial and aerial predators. Sea turtles typically do this under the cover of night. Within seconds of emerging from their nests, sea turtles begin crawling directly toward the ocean, which they apparently locate in the darkness by moving toward the brighter, lower oceanic horizon, and away from the shadowy silhouettes of shoreline vegetation. Once in the water, hatchlings use waves as a directional cue and unerringly head away from the shore. Eventually they begin to rely on an internal magnetic compass, which enables them to maintain a heading long after land is lost from sight, as well as when wave directions become inconsistent and confusing.

Left to right: Turtle Excluder Device in Mexican fishing net. Mazatlan harvest from the sea, 1967. Hawksbill *(Eretmochelys imbricata)*.
Cut out to right: Green sea turtle *(Chelonia mydas)*.

Alexander Vogel

Sonorensis 2002

Leatherback
(Dermochelys coriacea) hatchlings.

THEN AND NOW

The earliest marine turtles appeared in the Cretaceous period, best known as the last epoch of the dinosaurs, which were the ruling reptiles of the time. Since the demise of dinosaurs, 31 genera of sea turtles have navigated the planet. Today only 6 genera and 7 species remain. In the tropics, several have broad distributions, yet all are at risk of extinction and most are considered threatened or endangered. Knowing how to protect sea turtles requires detailed study of each species, which is why scientists like Dr. Jeffrey Seminoff have spent years studying small populations of the black sea turtle (a.k.a. East Pacific green turtle, *Chelonia mydas),* a unique, dark-colored morph of the green turtle, in and around the Gulf of California. Dr. Seminoff and his collaborators have examined the structure, diet, diving behavior, movement, and habitat use of the black sea turtle population. Their studies, ongoing since 1995, show that the size of adult turtles ranges from 38 to 86 centimeters and, surprisingly, only a small proportion of these are adult males. Dr. Seminoff and Wallace Nichols are finding that turtles captured near the Bahía de los Angeles feed primarily on red algae along with invertebrates such as sponge, soft corals, sabellid worms, and sea pens. In the coastal lagoons of the Pacific coast of the Baja Peninsula (also in the Infiernillo Channel of the Gulf), turtles feed almost exclusively on eelgrass. This variability in black sea turtle diet was formerly unknown.

Seminoff and Nichols have also documented, through telemetry data gained from radio sonic-tracked black turtles in the Bahía de los Angeles, that many turtles stay in the bay for long periods of time, from a few days to more than a year. These sea turtles were found to have a mean home range of 16 square kilometers, and foraged over a distance of about 9 kilometers per day. Acquiring such detailed information is a long and arduous task, but it is the only way we can develop a complete understanding of these mysterious animals and have any hope for ensuring their long-term survival.

IN THE END

Sea turtles figure prominently in the cultures of many native peoples. Green sea turtles, and to a lesser extent hawksbills, loggerheads, and leatherbacks, were major sources of meat for the Seri, an indigenous people of Central Sonora. Many other people consumed these turtles as well. In 1990, after most sea turtle population levels had crashed in the Gulf region, the Mexican government imposed an official moratorium on sea turtle hunting. Now the Seri can harvest only limited numbers of the turtles for special ceremonies. Clearly, successful conservation of sea turtles will demand collaboration with native peoples, and the study of these animals requires that we incorporate an understanding of their importance to local cultures. According to Seri mythology, the Earth rested on the back of a giant turtle that carried it forth from the depths of the underworld. If sea turtles are to continue to swim the seas, their future now rests upon our backs, and it is up to us to carry them away from the edge of extinction.

Top left: Green turtle *(Chelonia mydas)* surfacing from water. Lower left: Olive ridley turtle *(Lepidochelys olivacea)* nesting emergence. Lower middle: Turtle corral. Right: Green turtle in wreckage. Cut out below: Hawksbill turtle *(Eretmochelys imbricata)*.

UPDATE

Most sea turtle populations around the world continue to be threatened or endangered and are protected by many nations' laws and by international agreements. Advances in sea turtle conservation are occurring on many fronts, from deeper understanding of their basic ecology to better understanding of how humans and turtles can coexist. Some of these advances include community-based conservation (where biologists work with local communities to develop sustainable conservation strategies that benefit people and the environment), the use of advanced chemical techniques to document turtle food sources and foraging areas, the development of new methods to establish conservation priorities, and changing light sources on beaches where turtles hatch. One of the leading organizations in the area of community-based conservation is COBI (Comunidad y Biodiversidad), winner of the Desert Museum's Sonoran Desert Conservation Award in 2012. S

Debra Colodner, Ph.D.
ASDM
Director of Conservation Education and Science

Sonorensis 2002
Sonorensis 2002

Jesús M. García

TASTING HISTORY:

The Kino Heritage Fruit Trees Project

Jesús M. García
ASDM Education Specialist

&

Robert M. Emannuel, Ph.D.
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Several years ago, while restoring a centuries-old adobe structure at Tumacácori National Historical Park, park ranger David Yubeta encountered a peach pit fossilized within a decaying mud wall. This bit of archeological evidence became an important catalyst for future projects at the park. David realized that the history of this eighteenth-century Spanish mission – a history of stormy cultural contact, religious conversion, and technological transformation – went way beyond the remaining physical structures of this relic mission site. To the park ranger and his colleagues, the peach pit represented only the tiniest glimpse of the agricultural history of those who built the walls in front of him. David and others wondered about the origin of this pit – this product of an Old World species. Could the tree that produced it still be alive? After all, there are much older trees in the world. Even if the tree that produced the pit was long gone, might it have offspring that live today in some garden or orchard in the Southwest, Mexico, or even Spain? The quest to answer these questions has become an exciting horticultural and ethnohistorical endeavor for scientists and area residents alike.

A QUEST FOR HERITAGE FRUITS

In late 2003, a team of researchers from the Arizona-Sonora Desert Museum, University of Arizona, National Park Service, and other Tucson-area organizations assembled to create the Kino Heritage Fruit Trees Project. The project's first task was to identify fruit trees from the Spanish mission era by reviewing written accounts by Father Kino and other Jesuit missionaries, forty-niner diaries from the California Gold Rush, and the work of contemporary local ethnobotanists and horticulturalists. Most of the fruit trees and other plants

Jesús M. García

Dena Cowan

Dena Cowan

Left page: Josefina white pomegranate. Above left: Canyon de Chelly orchard. Above middle: Casimiro orchard, San Ignacio, Sonora. Above right: Tumacácori orchard, quinces.

in the mission farms were, indeed, native to the Old World. Others were native to the Sonoran Desert or Apache Highlands. Still others were native to other parts of North America. Also, we considered it pertinent to include on the Spanish-era list a few varieties of Sonoran Desert fruits that the Native Americans were likely to have shared with the Padres. These trees include black walnuts, acorns, hackberries, elderberries, and several species of columnar cacti, including saguaros and pitahayas.

The primary goal of the Kino Heritage Fruit Trees Project is researching, locating, propagating, and re-establishing historically appropriate Spanish colonial-era fruit tree cultivars to the original orchards and gardens at Tumacácori National Historical Park, in Tumacácori, Arizona, and to the Tucson Origins Heritage Park in Tucson, Arizona. We hope that these reintroductions will contribute to the interpretive, educational, and preservation objectives of these historic sites.

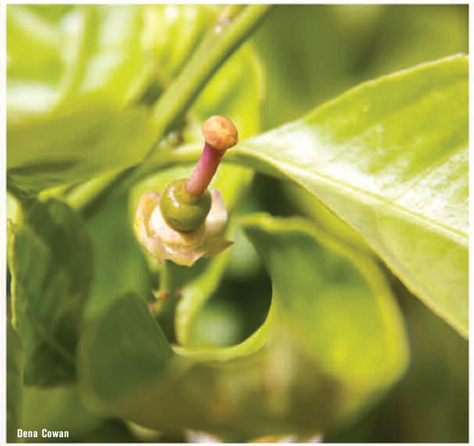
FARMS OF THE PIMERÍA ALTA

Our exploration began within the storied landscapes of the Pimería Alta, where Father Eusebio Francisco Kino received his permanent assignment in 1687. This culturally defined area is located in what is now northwestern Sonora, Mexico, and southern Arizona. The mountainous terrain of the Pimería Alta made it conducive to Kino's fruit tree introductions. First, a few of the river valleys experience both cold winters and warm summers. They also had perennial rivers – a critical ingredient for the success of water-hungry Old World trees. More importantly, however, the people of these valleys were already savvy farmers prior to the entry of the missionaries. They quickly put their agricultural skills to work on sustaining the new crops. They did this not just out of fealty to the strange pale-skinned newcomers but also because, like farmers everywhere, they recognized a good addition to the limited suite of crops they already produced.

When father Kino arrived in Pima territory, the native people of these valleys were already raising crops using irrigation systems. They cultivated cotton for clothing, and maize, beans, and squash for food. From a cultural history perspective, the establishment of European-style orchards and fields by Spanish missionaries catalyzed a process of agricultural transformation for Tohono O'odham, Sobaípuri farmers, and the later mestizo settlers (mixed-race inhabitants descended from Spanish and indigenous parents) that populated the Pimería Alta. These fruit trees now represent a critical part of the fusion of cultures that took place on mission

Sonorensis 2007


Dena Cowan


Dena Cowan


Jesús M. García

Left to right: Guari quince. Close up of sweet lime. Olives from the campus of the University of Arizona.

lands around the greater Southwest, starting in the late 1680s. After Father Kino's death in 1711, other European missionaries continued his work. Father Ignaz Pfefferkorn, a Jesuit assigned to the Pimería Alta in the mid-1700s, also described the quality of the fruits found in the missions: "In various places they planted a considerable number of these trees and produced pomegranate, peaches, apricots, quinces, figs, lemons, and oranges. These fruits are superior in size, juiciness, sweetness, and flavor to those in Europe."

The fruit trees appear again in accounts by the forty-niners traveling along the Santa Cruz River on their way to California gold. For example, one account by C.C. Cox in 1849 described the then decaying ruins of Tumacácori Mission. "The garden was well filled with full grown fruit trees, and they had been heavily laden with peaches, pomegranates, quinces, etc." What became of the trees in the half-century between the passing of these gold-seeking Argonauts and the twentieth-century designation of parks like the Tumacácori National Historical Park?

To answer this, we needed to gather oral histories of those who remember the early days of the twentieth century. For example, Tumacácori resident Agatha Cota Gastellum grew up in ranching communities near Tubac and Tumacácori. Now 95 years old, she still remembers the orchards her father had when she was a girl in the 1920s. "My father was a farmer. He had a little orchard around the house and grew grapes, peaches, apricots, quince, pomegranates, and other kinds of fruit that he experimented with. On his 160 acres he planted corn, beans, potatoes, tomatoes, garbanzos, fava beans, teparies, chile peppers, and watermelons."

While we can't be certain that all of the crops of the Gastellum family farm came from mission sites, we can make a logical argument for searching for these old homesteads and their contemporary remains in the neighborhoods of southern Arizona towns. In fact, backyards close to the mission harbor old trees of unknown parentage, potential offspring of those tended at Kino's missions. Further south in Sonora, farming towns like Magdalena de Kino and San Ignacio still support backyard and commercial orchards filled with unusually old trees. The same holds true for largely Hispanic neighborhoods near the old San Augustín de Tucson mission site. Only DNA wizardry could tell us for sure whether the trees came from those brought by Kino and his ilk, and we expect to employ this in the future. It is humbling to note, however, that these plants that grow among us very likely are the living legacy of the Spanish missionaries.

UPDATE

Since the reestablishment of the Tumacácori Mission orchard in 2007, it has been a great attraction for local residents and visitors from around the nation. The fruit trees have been thriving, with few exceptions. Recently, the Kino Heritage Fruit Trees Project has been instrumental in re-establishing the Mission Gardens in Tucson. This project is a re-creation of the Spanish Colonial walled garden that was part of Tucson's historic San Agustin Mission. It is located at its original site west of downtown at the foot of Sentinel Peak, also known as "A" Mountain. This effort has been spearheaded by a local nonprofit organization called the Friends of Tucson's Birthplace, whose mission is to preserve and foster the city's agricultural heritage. Thanks to successful fundraising activities more than 100 heirloom Kino trees, including figs, quinces, pomegranates, citrus, apricots, pears and grape vines collected in Southern Arizona have been planted and are all growing exuberantly. A state-of-the-art irrigation system has been installed and two shade ramadas have been built to serve as outdoor classrooms.

In addition to these institutionally supported undertakings, the Kino Heritage Fruit Trees Project is now entering a new phase. Its educational component has been inspiring individuals to create their own heritage orchards throughout the borderland region. As these backyard heritage orchards are being established, enriching Tucson with a sense of taste and history, the search for still-hidden heirloom treasures continues. S

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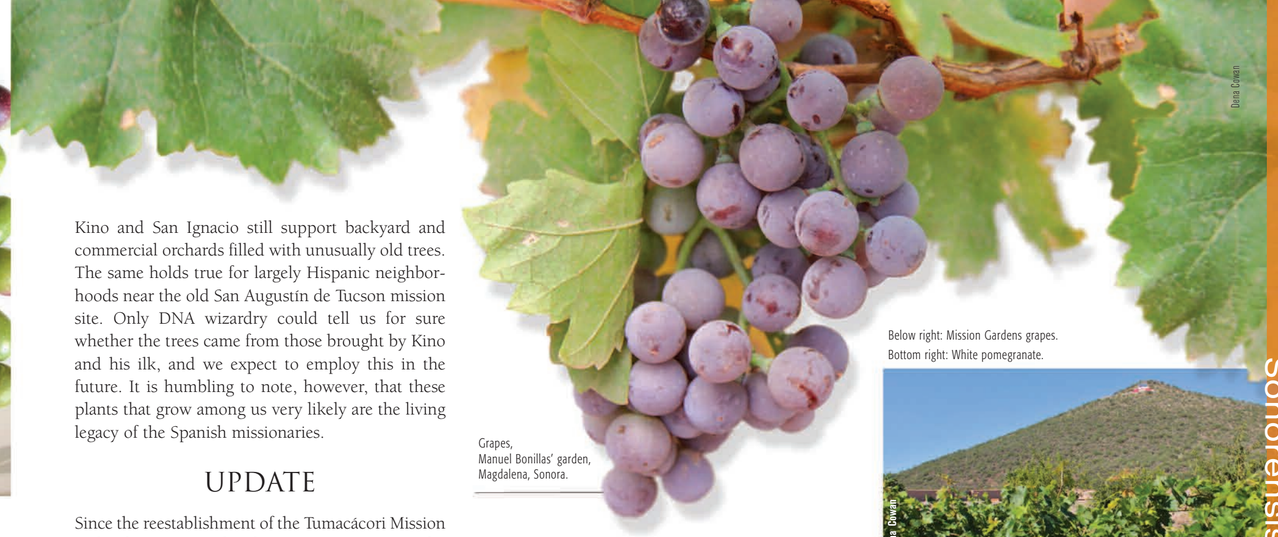
ASDM Education Specialist


Dena Cowan

Grapes,
Manuel Bonillas' garden,
Magdalena, Sonora.

Below right: Mission Gardens grapes.
Bottom right: White pomegranate.

Dena Cowan


Jesús M. García

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SEAFOOD AND THE SEA OF CORTEZ:
An Ecological Bouillabaisse


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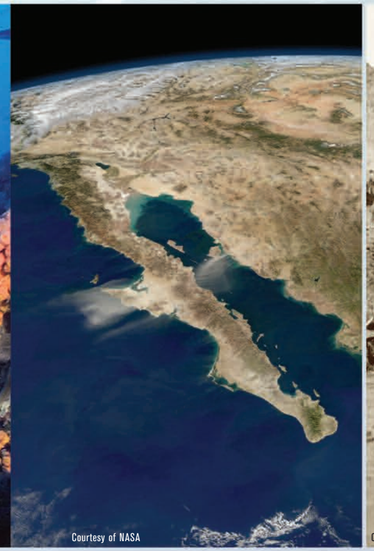

Courtesy of NASA


Courtesy of J. Seminoff

Richard C. Brusca, Ph.D.
ASDM Director Emeritus

Photography by **Richard C. Brusca,** unless otherwise noted

Cut out left: Lobster dinner. Above: Fish swimming near coral reefs off coast - Sea of Cortez.

Left above: The Sea of Cortez (Gulf of California) from space. Middle: Photo from 1937 showing the abundance of now nearly extinct totoaba, endemic to the northern Gulf. Right: Seafood market, Baja California. Cut out right: The historical importance of shrimp fishing in the Sea of Cortez is exemplified by this stunning monument to shrimp fishers in Puerto Peñasco, in the northern Gulf.

In this narrow gulf — as in all the world's oceans — up to 90 percent of the population of most predatory fish species has disappeared due to overfishing.

Nutritionists have known for decades that seafood is a premier source of top-quality protein, minerals, and vitamins (especially the important B-complex vitamins). Also, seafoods are low in fat and contain all nine essential amino acids – those that our bodies cannot manufacture on their own. And, ocean fishes contain 17 to 25 percent protein by weight. While that percentage is less than most meats, the protein in seafood is more readily broken down and absorbed than the protein in red meats and poultry. Furthermore, seafood contains substantial amounts of omega-3 fatty acids, a crucially important fatty acid that we can only obtain from the foods we eat. Recent studies indicate that eating seafood can decrease your risk of heart attack, stroke, obesity, and hypertension. So, for *Homo sapiens* there is no question that seafood contributes significantly to a healthful diet. But, what about the health of the marine environment and the impact that seafood harvesting has on marine ecosystems? Here in the Southwest, much (perhaps most) of our seafood originates south of the border, from the rich waters of the Sea of Cortez, or Gulf of California.

For thousands of years this saltwater heart of the Sonoran Desert harbored what seemed to be an inexhaustible supply of seafood. The legendary productivity (and fishing) of the Gulf inspired the likes of John Steinbeck, Ed Ricketts, Thor Heyerdahl, Jacques Cousteau, Edward Abbey, Ofelia Zepeda, David Quammen, John Janovy, Jr., and Ann Zwinger to explore and celebrate its natural wealth. With a watery surface of some 100,000 square miles, the Sea of Cortez reaches to within 50 miles of California and Arizona. Many North Americans eat from this wild but increasingly imperiled ecosystem, whether they realize it or not.

Since prehistoric times, seafood and shells from this great sea have been harvested and traded throughout the Southwest. In historic times, traditionally captured large predatory fishes – sea basses, groupers, corvinas, snappers,

Sonorensis 2009

Rick Brusca

M. Wicksten

Jennifer. Rupnow

EDI

Jennifer Rupnow

As a result of over-fishing, populations of large predators are now a mere shadow of what they were 40 years ago.

sharks, and the like – were harvested with no concerns for sustainability, as if their abundance could never be depleted. Thirty years ago, when I first started working in the Sea of Cortez, this was still the assumption. But no longer; given the dramatic fish depletions here and in the rest of the world's seascape, we can no longer delude ourselves with the myth of unending abundance.

In this narrow gulf – as in all the world's oceans – up to 90 percent of the population of most predatory fish species has disappeared due to over-fishing. Today, all of the traditionally fished species from the Sea of Cortez have been overharvested to the point of collapse, or near-collapse, of their commercial fisheries. Traditionally preferred finfish have been so reduced in numbers that many Mexican fishers now take virtually any fish they can catch, of any edible size. Decades of shrimp extraction have severely disrupted the seafloor ecosystem in much of the Gulf. Species once regarded as "trash fish" or "bycatch" – such as triggerfish, parrotfish, and skate – are now routinely sold in restaurants. How did we get here, and what can we do about it?

THE ECOLOGICAL DEPLETION OF THE SEA OF CORTEZ

Primary producers, algae and seaweeds that capture the sun's energy at the base of marine food webs, are especially abundant in this semi-enclosed sea. This high primary productivity is driven by year-round strong solar input, upwelling of nutrient-rich bottom waters continuously drawn into the Gulf from the open Pacific, and good circulation. And, this productivity has supported one of the world's most important concentrations of small oceanic fishes (such as anchovies, sardines, and mackerels), which in turn has provided critically important food sources for larger predatory fishes, jumbo squid, sea birds, marine mammals, and, eventually, humans. Beginning in the 1930s, however, a strong commercial fishery developed in this rich marine ecosystem, with some regrettable ecological impacts.

Remember John Steinbeck's little gem of a novel, The Pearl? The first fishery in the Sea of Cortez to be over-fished was the pearl oyster fishery of the La Paz-Cape Region, which drew Spanish colonists to the area in the 1600s and 1700s. Today, every commercial species in the Gulf is probably overfished, except perhaps jumbo squid, which only recently arrived in the Gulf of California in numbers large enough to harvest.

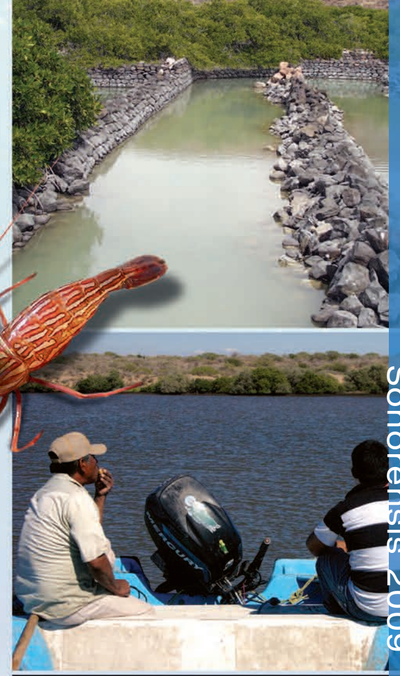
Today, the most important species for artisanal fishers are shrimp, jumbo squid, and clams. For the industrial fishery, the Pacific (or Monterey) sardine is the most important species, followed by shrimp, tuna, and squid. As traditionally sought large predatory fish have dwindled, industrial fishers have shifted increasingly to sardines and jumbo squid.

The shift in primary target species has had significant socioeconomic impacts, but it could have even more profound ecological repercussions. Sardines, anchovies, and jumbo squid are key elements of the Gulf's oceanic ecosystem. They represent species very near the bottom and top of the oceanic food chain, respectively. Their population sizes have direct effects on the rest of the food web, including the reproductive success of seabirds. There is a real danger that their over-exploitation could result in fundamental changes in the oceanic ecosystem.

Unsustainable fishing, bottom trawling, and environmentally-unfriendly shrimp farming are perhaps the most serious threats to the ecological integrity of the Sea of Cortez today. As a result of over-fishing, populations of large predators are now a mere shadow of what they were 40 years ago. Devastated populations include sea basses and groupers, sharks, some snappers, and even some jacks. Due to overfishing, some spawning aggregations of these and other large species – especially the goliath grouper and giant sea bass – may have entirely disappeared from the Gulf.

Most wild shrimp are captured by bottom trawling, "dragging" with heavy equipment that levels the seafloor – the undersea equivalent of clear-cutting forests.

Many less visible invertebrate species, also once-abundant, are also now rare here. Most wild shrimp are captured by bottom trawling, "dragging" with heavy equipment that levels the seafloor – the undersea equivalent of clear-cutting forests. The heavy chains on traditional trawl nets dig 15 to 30 centimeters into the seabed. For every kilogram of wild shrimp trawled, 10 to 40 kilos of additional bycatch are killed! Shrimp trawlers produce an inordinate percentage of the global bycatch – capturing less than two percent of the world's seafood by weight, but one-third of the world's bycatch. Worldwide, every year an estimated 150,000 endangered sea turtles are caught and dragged in shrimp nets until they drown. Shrimp trawlers kill more sea turtles than all other causes combined.



Top left: Tiny Isla Rasa is the major nesting area for both Royal and Elegant Terns.

Cut out: Giant sea bass *(Stereolepis gigas)*, like most large predators, was once abundant but is now greatly diminished in number and average body size in the Sea of Cortez.

Long-beaked common dolphin *(Delphinus capensis)* are frequently killed by drowning in gill nets that indiscriminately kill anything that gets trapped in their mesh.

Left: Industrial shrimp boat bycatch. For every pound of shrimp dragged from the seabed, 10 to 40 pounds of bycatch are killed. Right: A commercial boat's catch of Gulf grouper *(Mycteroperca jordani)*. This species, listed as endangered by The World Conservation Union (IUCN), is heavily over-fished.

Green sea turtle *(Chelonia mydas)*.

Top right: Pearl oyster lagoon built by Gastón Vives, Bahía San Gabriel, Espíritu Santo Island, in the southern Gulf.

Cut out: Gulf cleaner shrimp *(Lysmata californica)*.

Panga (small boat) fishers in southern Sonora, pondering their declining catch.

Sharks, once superabundant in the Sea of Cortez, are now rare due to overfishing.

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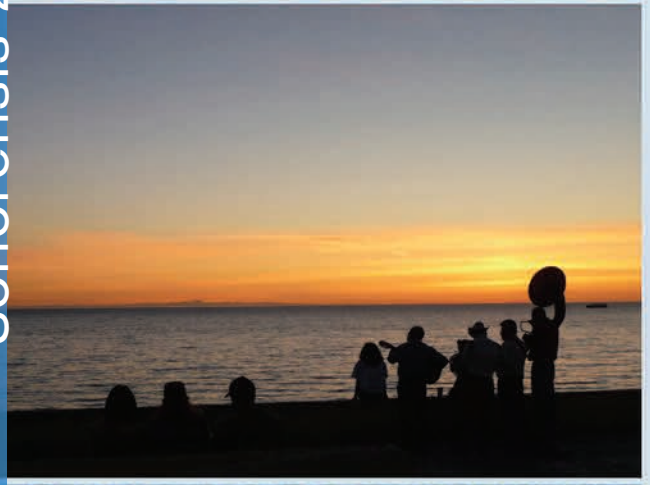


More than one-third of the seafood consumed in the world is now farm-raised.

A SPECIAL PLEA TO SOUTHERN ARIZONA RESTAURANTEURS

Please consider doing what the Ironwood Food Service's restaurants do at the Desert Museum – make a pledge to serve only sustainable seafoods. It's easy. Just dedicate your menu to seafoods in the "best choices" list in Monterey Bay Aquarium's Seafood Watch program. Delicious preparations are easy – think farmed bay scallops, Alaskan salmon and flounder, Pacific halibut, Maine or California spiny lobster, U.S. mahi mahi, U.S. pink shrimp (Oregon) and tilapia, and farmed mussels, oysters, and trout. In Monterey, California, over two dozen restaurants are now serving 100% sustainable seafoods. If they can do it, so can Arizona. Go sustainable, and let the Desert Museum help promote your good work!

For more comprehensive and updated coverage of sustainable seafood choices, visit the Monterey Bay Aquarium's Seafood Watch Program website at montereybayaquarium.org/cr/seafoodwatch.aspx.

Top left: Isla Danzante, one of over 900 islands in the Sea of Cortez, with the Baja Peninsula looming in the background.

Cut out: The increasingly rare regal murex *(Chicoreus regius)* is a large, beautiful snail consumed locally in the Gulf. This species is often brought up in shrimp trawls and other bottom nets; the shells end up in curio shops.

Cut out right: Frilled venus clams *(Chione undatella)* and Panamic cockles *(Trachicardium panamense).*

Fin whale, Sea of Cortez

The popular malecón in Puerto Peñasco, Sonora.

Floating tuna farms off the Pacific coast of Baja California

UPDATE:

Although most of the world's wild fisheries continue to be overfished, the good news is that recent research shows that Americans "are willing to buy and pay more for seafood that is healthy and sustainable" (The Ocean Project 2009). To aid consumers in making the best seafood choices, the Monterey Bay Aquarium has recently come up with the "Super Green" list, which includes seafoods that are harvested sustainably, are low in environmental contaminants, and are a good source of long-chain omega-3 fatty acids. At the top of this list you'll find albacore tuna (troll or pole-caught from the U.S. or British Columbia), freshwater Coho salmon (farmed in tanks in the U.S.), farmed oysters and rainbow trout, and wild-caught Pacific sardines. You can find many more sustainable and healthy seafood choices at the Monterey Bay Aquarium's Seafood Watch website referenced above. You can also download the Seafood Watch App which allows you to tag and recommend local purveyors of sustainable seafood. S

Kim Franklin, Ph.D.
ASDM Conservation Research Scientist

Bruce D. Taubert

Looking FORWARD

Clare Aslan, Ph.D., Kim Franklin, Ph.D. and Karen Krebbs
ASDM Conservation Scientists

Left to right: Karen Krebbs, Kim Franklin and Clare Aslan.

The Arizona-Sonora Desert Museum has a rich legacy of conservation research in the Sonoran Desert. Many of the themes that are explored in this issue of Sonorensis are also represented in current projects of the Conservation Education and Science Department at the Museum.

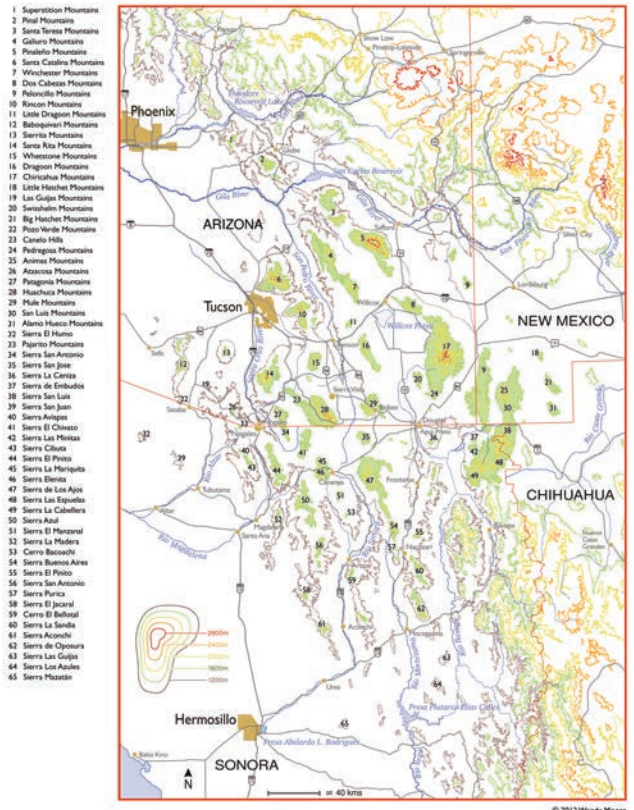
Major conservation concerns in the Sonoran Desert Region today include invasions by non-native species, the loss of riparian habitat as a result of groundwater depletion, and climate change, which poses a special threat to the species-rich communities that reside in the Sky Island mountain ranges of the Sonoran Desert. Many of the species confined to our Sky Islands will become increasingly isolated as their habitats shrink and the desert spaces between mountain ranges become more difficult to cross. To examine these issues, the Museum's current research staff brings expertise in Sonoran Desert vertebrates, arthropods, plant-animal interactions, and invasive species. Additionally, Museum researchers continue to build upon the history of ASDM pollination studies, such as the Forgotten Pollinators Campaign and the Migratory Pollinator Program.

Our mission at the Museum is to conserve the biodiversity of the Sonoran Desert for future generations. The science staff plays a critical role in that mission by conducting studies designed to answer key ecological questions that must be addressed before effective conservation measures can be developed. Currently at the Museum, Kim Franklin is exploring the diversity of insect species in Sky Island habitats, Karen Krebbs is tracking bat populations and trends over time and Clare Aslan is evaluating the effectiveness of ongoing pollination of endangered species. All are working with partners at federal, state, and local agencies, universities, and non-profit organizations to describe the biodiversity and natural history of sky island and oceanic island systems in the Sonoran Desert and the Sea of Cortez.

Sky Island habitats are expected to be particularly affected by climate change. As temperatures rise, species are moving higher. This reduces the total area of their habitat and isolates them from patches of similar habitat on other Sky Islands. Animals such as birds and bats may move away from Sky Island habitats altogether. Long-term research projects in the Sky Islands can detect changes in species distributions and interactions. Museum researchers are charting biodiversity in the Sky Islands and determining which species are currently present at different elevations. By comparing this new information with historic records, we can examine how changes in climate are influencing species diversity in the region and can identify the species most threatened by these changes.

Research occurs both on and off the Museum grounds. With the help of volunteers, the research staff is looking to document pollination of cacti in the Museum's gardens. Offsite, pollination work has been carried out or is underway at Tohono Chul Park, the White Mountains, the Chiricahua Mountains, other Sky Islands, and throughout much of Sonora, Mexico.

Our research and education outreach efforts convey the importance of conserving and understanding this unique ecosystem. Research generates knowledge, and knowledge can be shared through education to facilitate appreciation and conservation. The Sonoran Desert is a place of both rich biological diversity and a vibrant cultural heritage. We invite you to share in our wonder of this place. S



SKY ISLAND ARCHIPELAGO

Cut out upper left: Nectar bats *(Leptonycteris curasoae yerbabuenae).*

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The earth is not wanton to give up her best to every comer,
but keeps a sweet, separate intimacy for each.

—Mary Austin