

Sonorensis

ARIZONA-SONORA DESERT MUSEUM

2015

SAVING SPECIES
CONSERVING

Life



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Cover: Monarch butterflies grace the sky and blanket tree branches in the Monarch Butterfly Biosphere Reserve in Michoacán, Mexico. Photo by Noradoa/Shutterstock.

Back cover: A neonate olive ridley sea turtle reaches the sea. Photo by Aneese/Shutterstock; *A Natural History of the Sonoran Desert*: Catalina State Park, Arizona. Photo by Jack Dykinga.

We gratefully acknowledge all the authors, photographers, and organizations who contributed articles, photos, or maps for this issue of *Sonorensis*.

Photos on this page, above: California least tern (*Sternula antillarum brownii*); California tiger salamander (*Ambystoma californiense*).



Robert McMoran, FWS NCTC

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Contents

1	Introduction <i>Kim Franklin, Ph.D.</i>
2-5	The Tale of the Monarch <i>Ruscena Wiederholt, Ph.D. & Kaitlin Libby</i>
6-11	Top Predators in our Midst <i>Sergio Avila</i>
12-17	Vaquita: Can Mexico's Desert Porpoise Be Saved? <i>Barbara Taylor, Ph.D., Lorenzo Rojas-Bracho, Ph.D., & Armando Jaramillo-Legorreta, Ph.D.</i>
18-21	Toward Species Recovery: The Desert Ark Revisited <i>Craig S. Ivanyi & Debra C. Colodner, Ph.D.</i>
22-26	From an Owl Flap to Landscape Conservation: The Sonoran Desert Conservation Plan <i>Brian Powell & Julia Fonseca</i>
27-29	Not Just Doom and Gloom: Bright Lights in Conservation <i>Rodrigo A. Medellín, Ph.D.</i>

SAVING SPECIES CONSERVING Life

INTRODUCTION

Kim Franklin, Ph.D.

*Conservation Research Scientist,
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Our dependence on clean air and water needs no explanation, but why save species? When Congress passed the U.S. Endangered Species Act (ESA), it recognized the “esthetic, ecological, educational, recreational, and scientific value” of biodiversity. Biodiversity is the foundation of life itself. It provides us with functional ecosystems in which fundamental processes such as photosynthesis, decomposition, and nutrient cycling take place, providing us with essential services such as filtration of air and water.

Although the ESA was groundbreaking protection legislation in the United States, it was not the first. The Lacey Act of 1900 was passed to address growing public concern over the imminent demise of the passenger pigeon. It was the first federal law protecting wildlife. Awareness continued to grow, and in 1966, Congress passed the Endangered Species Protection Act to “conserve, protect, restore, and propagate” species on an official list of threatened and endangered species. The first list contained 78 species, all of which were vertebrates. In 1973, the passage of the ESA extended coverage to plants, insects, and smaller taxa. Today, it protects more than 1500 plant and animal species. In addition, most U.S. states have their own endangered species laws. In 1983, the Arizona Game and Fish Department (AZGFD) instituted the Nongame and Endangered Wildlife Program, which manages all nongame wildlife and endangered species within Arizona. AZGFD has also taken the lead on some species reintroductions, such as that of the Mexican gray wolf.

Mexico has also stepped up to the plate to protect endangered species and natural resources. The Office of the Attorney General for Environmental Protection (PRO-FEPA) was created in 1992, and the Ministry of Environment and Natural Resources (SEMARNAT) in 1994, when the Law for Endangered Species Protection was also passed. These organizations take a major role in protecting species at risk, as you will note in this *Sonorensis*. Finally, in 2000, Mexico



Cynthia Rubio, PNS Photo (<http://myd.as/p6142>)



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Kane513

Above, and clockwise: monarch butterfly (*Danaus plexippus*); Kemp's ridley hatchlings (*Lepidochelys kempii*); California condor (*Gymnogyps californianus*); least bell vireo at nest (*Vireo bellii*); peninsular pronghorn (*Antilocapra americana peninsularis*); masked bobwhite (*Colinus virginianus ridgwayi*).

“What good is it?” If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.” – Aldo Leopold, Round River: From the Journals of Aldo Leopold.

initiated the National Commission of Natural Protected Areas (CONANP), which protects 60 million acres, more than one third of which are along the U.S.-Mexico border!

There are many private organizations and local/regional governments striving to save species and habitat in the Sonoran Desert Region, as well—too many to list here. The need is recognized and the will exists, but the practical and political paths to species recovery are being freshly cut through difficult terrain. Each attempt is based on the best available science, but there is much yet to learn. Zoos and aquariums are among the players making valuable contributions to recovery programs. Currently, ASDM keeps, breeds, or exhibits 29 endangered species, 8 of which have been released into the wild.

The success or failure of the ESA has been hotly

debated. Some view the small number of species delisted as a failure, but a recent report by the Center for Biological Diversity points to a high percentage of species on the path to recovery, which, for many species, may take decades. In this issue of *Sonorensis* we look at current efforts to save endangered species, including two top predators, the planet's smallest porpoise, and a frog and snake endemic to the Sonoran Desert Region. We also tell the story of a charismatic butterfly whose epic migration and healthy populations are at risk. We consider both international and local conservation approaches, such as the Pima County Sonoran Desert Conservation Plan. We look at existing challenges as well as successes in saving species at risk. We hope these stories help more people understand, appreciate, and conserve the treasures of our amazing Sonoran Desert. ■

THE ENDANGERED SPECIES ACT (ESA)

- passed in 1973 after the Clean Air Act (1963) and Clean Water Act (1972), among other environmental legislation
- administered by the U.S. Fish and Wildlife Service (USFWS) and by the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration (NOAA).
- requires designation of critical habitat and preparation of recovery plans for listed species.

Listing under the ESA

- based solely on science, not economic and social concerns
- endangered = a species in danger of extinction throughout all or a significant portion of its range
- threatened = a species that is likely to become an endangered species within the foreseeable future . . .

THE TALE OF THE *Monarch*

In the Wiederholt yard, when I was a child, there was a narrow garden between the house and the driveway that sprouted roses, columbines, and milkweed. There, in northeastern Wisconsin, the milkweed bloomed each fall, sending downy seeds across the landscape. In the summer, I would look for holes in its leaves, for that meant the monarch butterflies had returned. Lifting the leaves, my sisters and I found fat yellow-and-white caterpillars munching away. A few weeks later, we searched for the chrysalids (the encased pupae), to put in jars. We'd watch the shiny green pods that darkened at the very end—just like in our elementary-school books. When the adult monarchs emerged, slowly flapping their wings, we'd release them outside to fly away, never to be seen again. Once, we found a monarch whose wings had formed improperly, bent hopelessly for flight. I tried to rescue it, bringing it nectar in the form of flowers and sugar water. Unfortunately, that butterfly didn't make it, but it left an imprint on my mind—one that's lasted nearly 25 years.

Ruscena Wiederholt, Ph.D.,
Assistant Research Scientist, School of Natural Resources and the Environment & the Udall Center for Studies in Public Policy, and
Kaitlin Libby, Student, Environmental Studies and Information Science and Arts, University of Arizona

My childhood fascination with monarchs (*Danaus plexippus*) is not unusual. The monarch butterfly is a celebrity of nature. It is treasured around the world by people of all age groups and backgrounds, admired for its delicate beauty and amazing resilience, and for the mystery of its mass migrations. Unwittingly, we admire them because of the heritage each butterfly possesses in its DNA—because not a single monarch that leaves the fir forests of Michoacán in early spring will arrive to summer in Maine. Rather, each butterfly returning to their summer home will be a multiple-generation offspring of those that left the mountains of central Mexico. It is a feat



Above: Monarch butterfly caterpillar on common milkweed leaf. Right: Monarchs overwinter in the Monarch Butterfly Biosphere Reserve, Michoacán (Mexico). Left page: Monarch on *Asclepias curassavica*.

that has amazed and puzzled the best minds. Impressively, although the long journey north in spring takes several generations, many individuals actually make the whole return trip—thousands of kilometers—back to Mexico in the fall.

While most of the monarchs migrate from central Mexico to the northern United States and Canada east of the Rocky Mountains, a smaller population of butterflies overwinters on the coast of California and spreads west in the summer. The Sonoran Desert Region is essential to the migration of both the monarchs that fly to the west of the Rockies and those that fly south to Mexico. Desert flowers provide these gentle creatures with nectar for nourishment, and various milkweed species feed the larvae (caterpillars) that grow and metamorphose to fly the next leg of this multi-generational journey.

But the phenomenon of the magical monarch migrations is at risk as the once-thriving populations of the monarch decline, in large part due to habitat loss, climate change, and dwindling larval food plants. This plight highlights an essential problem in large-scale conservation and environmental concerns—if all steps in the monarch's journey are not preserved, beyond its brief solace in Arizona and journey to Mexico or to the groves of California, the

paper-winged dance of a monarch butterfly will no longer be seen and appreciated, and their ecological niche will collapse. While monarch butterfly larvae sequester poisonous chemicals from milkweed, they are still a prey item for many species that don't seem to be bothered by these chemicals. They are an important food source for many species of mice, birds, insects, spiders, and hosts for bacteria and viruses.

PORTRAIT OF THE MONARCH

Monarchs are the official insect or butterfly of seven U.S. states, the emblem of Quebec, and the representative insect of Michoacán, the Mexican state where they overwinter. The traditional belief of the indigenous Otomies and Mazahuas in Michoacán is that the monarchs, which returned around the time of the Day of the Dead, are the souls of their ancestors. In Tucson, Arizona, the All Souls Procession, which pays tribute to loved ones passed, includes a troupe of monarch-wing wearers who honor the butterfly.

The wingspan of this vibrant orange and black butterfly is typically 3.5 to 4.5 inches (~9-11 cm). Their wings are rimmed with white spots, and males can be distinguished from females by a darker black spot on their lower wings. They weigh about the same as a paperclip, yet they can travel thousands of kilometers. Monarchs start their annual cycle in the oyamel fir (*Abies religiosa*) and pine forests of the mountains of Michoacán and the neighboring State of Mexico. There, they cluster in dense colonies, covering trunks and tree branches in numbers so great that branches bend under their weight, and aerial photographs of the oyamel forests during





Jef Vanuga, USDA NRCS



Jim Honcoop/ASDM Digital Library

their residence have an orange hue. In spring, they start their migration north. They move first to the southern United States, and then spread out like a wave, migrating to the Midwest, Northeast, and eventually reaching southern Canada. Arizona is unique in that it harbors butterflies from both the eastern and western populations, and some populations even overwinter here. Monarchs are also found in Central and South America, Australia, Micronesia, the Madeira and Canary Islands, and even Spain and Portugal. We don't know for certain how they arrived in these places, but it is likely humans are the cause of this dispersal.

As monarchs migrate, they feed on nectar sources—such as goldenrods, asters, clover, and alfalfa—that provide necessary carbohydrates for flight, as well as energy stores for overwintering. They lay their eggs on milkweeds, plants in the genus *Asclepias*, which the larvae require to survive. Depending on a “weed” for reproduction, however, can have its downfalls. Nearly 1.1 billion milkweed stems (one plant can have multiple stems), about 48% of the total number, are estimated to have disappeared between 1999 and 2014 from the midwestern United States, a key breeding area for monarchs. While some of this loss is due to land conversion, the vast majority is due to an increased use of glyphosate herbicide with the widespread planting of genetically-modified, glyphosate-tolerant crops (a.k.a. Roundup Ready crops). In 2014, 94% of soybeans and 89% of corn planted in the United States were glyphosate-tolerant. High herbicide use means fewer milkweeds, and as we've been seeing, fewer monarchs. The decline of the Eastern population of monarchs has raised international concern.

FALL OF THE MONARCH

Monarch population size is measured in the overwinter colonies in hectares; it is estimated in area instead of numbers of individuals because overwintering colonies contain literally millions and millions of tightly clustered monarchs, making accurate counts of them nearly impossible. On the other hand, the area those colonies occupy can be measured

Above left: Monocultural field being sprayed with pesticides. Left: Other species also use milkweed. Here, a purple hairstreak (*Favonius quercus*) on *Asclepias linaria*.

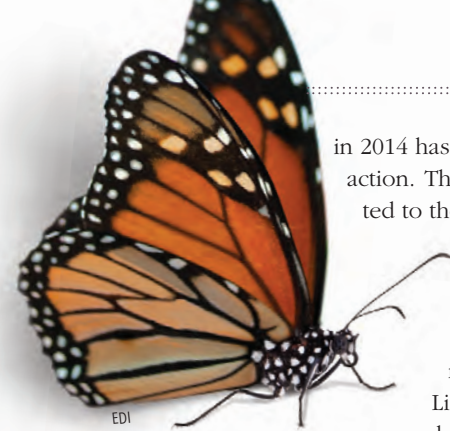
accurately, and this approach has been used since 1993. Unfortunately, in the winter of 2013-2014 scientists recorded the lowest population estimate ever: it was only 44% of the previous year and about 10% of the average population size over the past 20 years. While the following winter, 2014-2015, had a slightly higher population estimate than the 2013-2014 estimate of 0.67 hectares, the numbers were still quite low—1.13 hectares (as opposed to the average of just over 6 hectares for the 20 years previous to 2013-2014). The western population that overwinters in California has also declined, but has not experienced such precipitous drops in the last two years.

Although the loss of milkweeds is a major driver of monarch decline, it is not the only one; these butterflies face a long list of threats. For instance, habitat losses due to illegal logging in their overwintering sites are a contributing factor. Water diversions and tourism may also disturb overwintering sites in Mexico. Fortunately, efforts by Mexican authorities (SEMARNAT/PROFEPA) and others (such as the USFWS Wildlife Without Borders-Mexico program), the establishment of the UNESCO World Heritage Monarch Butterfly Biosphere Reserve in 2008 (which preserves more than 56,200 hectares), and the generation of alternative local income and employment has largely slowed illegal logging in the overwintering grounds.

Monarchs are also attacked by parasites and diseases. Widespread use of pesticides such as neonicotinoids (which are implicated in the decline of both insects and birds where studies have been carried out) are known to cause delayed development, neurological and behavioral changes, and elevated mortality rates in pollinators, and likely harm monarchs. Finally, climate change and extreme weather events are important determinants of both monarch survival and reproduction. For example, in 2002, a severe winter storm in the overwintering grounds in Michoacán killed an estimated 500 million monarchs due to wet and freezing conditions. That number is nearly nine times the population size this year. Unfortunately, climate change models predict a decrease in the suitability of monarch habitat in their overwintering grounds and potentially in the monarch's northern range.

GRAND-SCALE CONSERVATION

While the list of threats is sobering, hope is not lost for this iconic migratory species. The abysmal population size



in 2014 has spurred renewed conservation action. That year, a petition was submitted to the U.S. Fish and Wildlife Service by the Xerces Society, the Center for Food Safety, the Center for Biological Diversity, and renowned monarch researcher and advocate Dr. Lincoln Brower to list the monarch as a threatened species. In addition, the need to conserve monarchs was highlighted in a meeting between the leaders of Mexico, the United States, and Canada—resulting in focused conservation efforts by federal agencies in each country. These efforts must take a variety of forms. Land restoration strategies for monarchs that increase nectar sources and milkweed will be key. Improving habitat in a variety of areas including agricultural land removed from production through the U.S.D.A.'s Conservation Reserve Program (CRP) lands, public and private lands, roadsides, and agricultural areas will help their recovery. CRP land could provide improved habitat by encouraging farmers to include flowering plants (including milkweed) in seed mixes used to replant grasses. Roadsides are all too often mowed and sprayed with pesticides that kill milkweeds and other nectar sources; however, if properly managed, roadsides, along with other right-of-way lands, yards, and fencerows (where they still exist), could provide important monarch habitat. In fact, in May of 2015, the U.S. government announced a plan to help reverse the decline of bee and monarch populations by restoring 7 million acres with a greater diversity of flowering species—from roadsides to urban properties and beyond.

Residents in the Sonoran Desert Region can help by planting monarch-friendly (pesticide-free) native milkweeds. Plants from nurseries may be pre-treated with pesticides. As it happens, Arizona is one of the most biodiverse states for milkweed species. The Xerces Society for Invertebrate Conservation provides a milkweed seed finder and sources of information about growing milkweed (see Suggested Readings and Resources). In addition, most local native plant nurseries will carry at least one native species of milkweed. Look for them at the Desert Museum plant sales. The Monarch Watch Milkweed Market also sells milkweed plugs.

Monarchs are also the subject of multiple citizen-science projects that track juveniles, adults, and disease dynamics, which helps scientists studying monarchs and their decline. Southern Arizona has citizen-science efforts such as the Southwest Monarch Study, which tags butterflies and grows native milkweed. This paradigm shift toward citizens who can participate in research encourages conservation practices and increases our knowledge of this charismatic species.

Since the monarch's range in North America extends into three countries, we cannot focus on regional conservation strategies alone—the best way to help monarchs is through coordinated and broad conservation actions across the multiple regions, including the Southwest. Bringing back native biodiversity across large landscapes will help not just monarchs, but many other pollinators, including bees, bats, hummingbirds, moths, flies, wasps, beetles, and other species of butterflies. ■

SUGGESTED READINGS AND RESOURCES

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Oberhauser, Karen S., Nail, K. R., and Altizer, S., eds. *Monarchs in a Changing World: Biology and Conservation of an Iconic Butterfly*. Ithaca, NY: Cornell University Press, 2015.

Monarch Watch Milkweed Market
<http://monarchwatch.org/milkweed/market/>.

Xerces Society for Invertebrate Conservation
<http://www.xerces.org/milkweed-seed-finder/>) and (<http://www.xerces.org/milkweed/>).

Mariposa Monarca - Monarch Butterfly Biosphere Reserve, in Spanish <http://mariposamonarca.semarnat.gob.mx/> with video: <http://mariposamonarca.semarnat.gob.mx/multimedia.html>

Above right: Butterfly with tag visible in little girl's hand. Right: ASDM staff and docents tagging monarchs for the Southwest Monarch Study.



Albert Herring, VA State Parks; creativecommons.org/by/2.0/deed.en



Photo courtesy Southwest Monarch Study



Destiny Wedding Studio

TOP PREDATORS

IN OUR MIDST

Serio Avila,
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El Tigre

I walked along a canyon on the western slope of the Sierra Madre Occidental, Sonora—a canyon I'd walked every day for three months—and the trees, rocks, and creek were all familiar to me. Turning a bend, I saw an old mesquite tree, with its large curved trunk and broad, dense canopy; nothing stirred, no noise could be heard. Then, my eyes fixed on a large shadowy form moving from behind the tree. Although it was shaded by the canopy, I was able to make out a huge head with small ears popping up behind a nearby rock. My first thought was, "Wow, this is the largest mountain lion I have ever seen." I lowered my backpack and reached for the camera. It was, in fact, el tigre.

El tigre, the jaguar (*Panthera onca*) is the largest wild cat in the New World, and while the northern jaguar of the Sonoran Desert Region is smaller than its brethren to the south, it is still larger than a mountain lion. Hunting primarily at dawn or dusk, this obligate carnivore has powerful jaws, huge eyes, and large canine teeth. It pads through montane habitat in woodlands and forests, or in thornscrub, and unlike most cats, it likes water. It also differs from other wild felines in its willingness to eat carrion.

In 2003, when I photographed that jaguar, I lived for five months in a remote area of the Sierra Madre of Sonora, invited there by Mexican jaguar expert Dr. Carlos López-González, coauthor of *Borderland Jaguars* with Dr. David Brown. Efforts



Ana Realavia

by the Northern Jaguar Project and the Mexican nonprofit Naturalia A.C. to purchase lands for the protection of this northernmost breeding population had barely begun. Today, that area holds the Northern Jaguar Reserve, a 58,000-acre system of properties near the confluence of the Ríos Aros and Bavispe (which come together to form the Rio Yaqui), where Sonoran Desert scrub, Tropical Deciduous Forest, and oak woodlands converge. Its canyons and ridges host a tremendous diversity of plants and animals.

I was there leading a small field team to monitor jaguars and mountain lions using remote cameras, telemetry, and identification of tracks and other sign. The project was part of a larger effort to understand the jaguar's habitat and food preferences, the size of their territories, their migrating corridors, and their interactions with other wildlife species in the northern end of their range. After months of setting up and checking leg-hold snares daily, we captured two jaguars, a female and a male, and five mountain lions, a female and four males. We anesthetized each cat, released it from the snare, checked its condition, gender, weight, and estimated age, and fitted each with a radio collar. The field team followed the cats'

radio-collar signals every day, assessing their daily movements. This data allowed us to estimate their territory, and through field observations, telemetry locations, and remote camera photos we see how territorial jaguars and mountain lions share resources in space and time: they prey on the same species, but avoid each other by patrolling and hunting in different areas, or at different times of the day. From this northernmost breeding population in east-central Sonora, Mexico, jaguars travel north into the United States. These Sonoran jaguars are the hope for jaguar recovery in the United States, and the protection of corridors that connect their breeding grounds in Mexico with potential habitat in the southwestern U.S. is critical for this species.

"The largest mountain lion I've seen." Jack Childs and Warner Glenn must have thought something similar when they saw jaguars in Arizona's borderlands in 1996. (Their stories were shared in *Sonorensis*, 2008.) The sightings stirred excitement in southern Arizona, and they spurred new studies and stepped up conservation efforts for this handsome spotted cat.

In historic times, the jaguar had been known as far north as the Grand Canyon, where a female was shot in 1932; in 1963 a



Photo courtesy of the Northern Jaguar Project/Naturalia

Above: November 2014, a motion-triggered camera captured this image of a male jaguar on the Northern Jaguar Reserve (about 125 south of the U.S.-Mexico border), an area with the highest numbers of northern jaguar sightings in recent years, including females and cubs. Opposite page: Jaguar. Below left: Mountain lion (*Puma concolor*). Below right: A jaguar in southern Arizona, 2010, recorded by a remote camera.



Paul Bergquist

Sky Island Alliance

An update on Macho B

In 2009, the year after our feature on Macho B in *Sonorensis*, this male jaguar was illicitly captured in a snare and fitted with a radio collar. He had been repeatedly photographed for 13 years, but soon after the collaring, the injured and dehydrated jaguar was recaptured, transported to the Phoenix Zoo, and finally euthanized. Sadly, the zeal to learn about this mature jaguar was not balanced against the risks of collaring, nor the importance of it being the only known resident jaguar in the United States at the time.

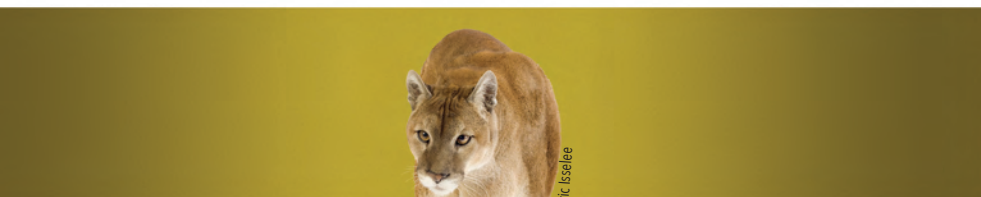


Sergio Avila

Above: Whetstone Mountains, a small part of jaguar territory. Below: A remote-camera photo taken in 2011 records the nocturnal passage of jaguar in northern Sonora.



Sky Island Alliance



Eric Isselee

female was killed in the White Mountains. Sightings in the 1880s put them along the Platte River in Colorado. But by the late twentieth century they had been entirely exterminated north of the border by the hunting, trapping, and poisoning of “nuisance animals.” In 2008, researchers estimated that 100 to 150 jaguars lived in the entire Sonoran Desert Region, almost all of them in northern Sonora. They were already listed as endangered in both Mexico and the United States, but lacked the benefit of recovery efforts in the United States, as mandated in the Endangered Species Act. Given the construction of an impermeable border barrier, poaching, and the impacts of climate change, the future for jaguar in this region did not look good.

Since then, positive steps have been taken. Here’s an update:

- In early 2009 the U.S. District Court ordered the U.S. Fish and Wildlife Service to initiate recovery efforts for the jaguar.
- In 2010 and 2011 at least three separate jaguars were photographed with remote cameras in the Huachuaca Mountains of Arizona and in the Sierra Azul of Sonora (30 miles south of the Patagonia Mountains.)

- In 2012, the University of Arizona launched the Jaguar Survey and Monitoring Project to search for and monitor jaguars with remote cameras in 16 mountain ranges across southeastern Arizona. To date, with remote-camera photographs and videos, they have recorded the continued presence of one male jaguar in the Santa Rita Mountains three years running. Tracks clearly showing the round, heavy proportions of a jaguar paw have also been found there.

- In March 2014, the U.S. Fish and Wildlife Service designated almost 765,000 acres of public lands in Arizona and New Mexico as critical habitat for the jaguar. These lands, in addition to private conservation properties in Sonora, provide stepping-stones for the cats to move north and south to the Sky Islands there.

- Since 2011, the Northern Jaguar Project and Naturalia added another 14,000 acres to the Northern Jaguar Reserve to bring it to the current total of 58,000 acres of protected reserve lands. They also work with ranchers in a buffer zone surrounding the reserve, which currently incorporates an additional 51,000 acres of protected habitat. (Rancher participation is based on signed agreements that they will not hunt, poison, trap, bait, or disturb wildlife on their properties.) Together, the reserve and



these partnering ranches cover 170 square miles of land, where more than 50 individual jaguars have been recorded since 2003.

Although progress is being made, it is slow. And as our human populations expand, it is urgent that we understand the important role the big cats play in ecosystems. (See “Apex Predators Play a Part,” page 11.) This knowledge fosters our appreciation and can motivate us to address public policies regarding their protection. It can help us be tolerant of the challenges and compensate for occasional “infractions” predators may levy on livestock. Finally, in order to conserve far-ranging species like jaguars and wolves, we must focus on complex, landscape-level conservation strategies. Saving these large charismatic mammals will take public support for conservation policies and participation in the public process. Apex predators evolved with a role in the natural world; their loss would be our loss.

Mexican Gray Wolf

Adapted from *Vanishing Circles*, ASDM Press, 2010
 Little more than a century ago, thousands of Mexican gray wolves (*Canis lupus baileyi*) ran freely across mountains, grasslands, and shrublands from central Mexico

Critical Habitat

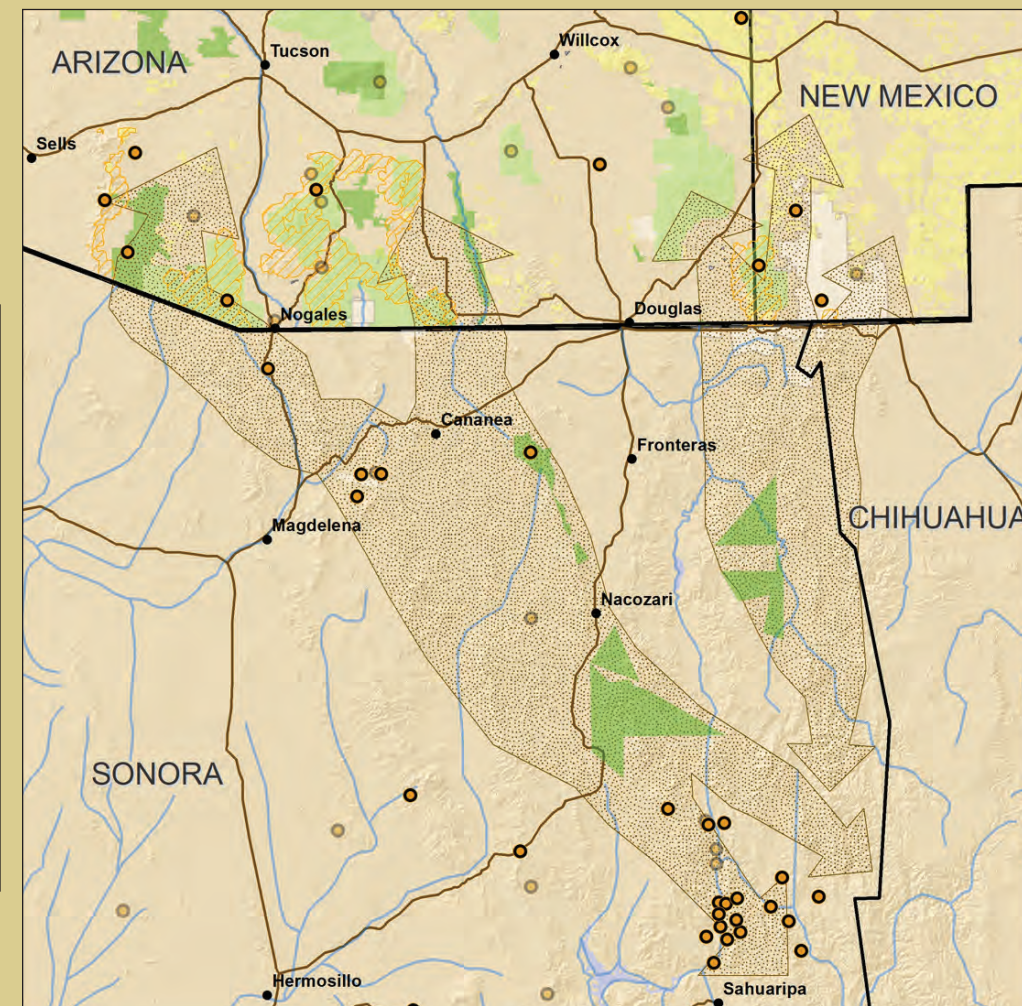
In the United States, critical habitat is a specific geographic area considered essential for the conservation of a threatened or endangered species. It is designated by the U.S. Fish and Wildlife Service under the ESA after a proposal and consideration of public comments; it ensures that federal actions will not compromise habitat necessary to the survival and recovery of the named species. Critical habitat status does not affect land ownership or establish a refuge, preserve, or other conservation area. It generally has no effect if a federal agency or action is not involved—for example, when a landowner undertakes a project on private land that involves no federal funding or permitting. A study published in 2005 in *BioScience* found that plants and animals with federally designated critical habitat are more than twice as likely to be moving toward recovery as species without it.

JAGUAR TERRITORY

Map by Samantha Hammer/Sky Island Alliance

Legend

- Jaguar occurrences since 1990
- Jaguar occurrences before 1990
- ▨ Designated Critical Habitat
- ▤ Jaguar Movement Corridors
- BLM Lands
- Protected Private Lands
- Protected Federal Lands
- National Forest





Above: Mountain lion and cub. Below: Mexican gray wolf.



to Colorado; today, most of the surviving Mexican gray wolves are in zoos. In this subspecies, the smallest of the gray wolves, adult males weigh up to 80 pounds, with the females less hefty. Intelligent and social, these wolves travel and work together in packs, generally with a life-bonded pair and some or all of their offspring. They will hunt a territory of hundreds of square miles if necessary, according to the abundance of deer, elk, pronghorn, and other prey.

When settlers arrived in force to the Southwest, many saw the wolf as a competitor, a threat to livestock and livelihood, and in 1915 U.S. federal and state governments, along with ranchers and bounty hunters, went to war against the wolf using guns, traps, and poisons until, in the early 1970s, *el lobo's* impending demise was clear. But by that time, ecologists had gained a better understanding of the essential roles of top predators in food webs and ecosystem health. Public sympathies had also been turned by a growing conservation movement.

Near extinction, *Canis lupus baileyi* showed up on the U.S. Endangered Species List in 1976. But by 1975, Desert Museum staff was already contributing to plans

for re-establishing Mexican gray wolves in the wild. A male Mexican gray wolf donated to the Desert Museum in 1959 and a female we received in 1960 had already bred pups—they were the first of only three genetic lineages of Mexican gray wolves extant today, the Ghost Ranch lineage. By 1980, five of the last remaining wild Mexican wolves were captured in Durango and Chihuahua, Mexico, and brought to the United States for captive breeding programs now managed under the American Zoo and Aquarium Association's Species Survival Plan Program. They engendered the McBride lineage. The third of the genetically verified lineages, the Aragon lineage, came from the Chapultepec Zoo in Mexico City. These three lineages now provide the only stock for reintroduction programs. (The wolves currently on exhibit at ASDM are a mix of all three lineages).

Into the Wild

The first eleven Mexican gray wolves were released into the Blue Range Wolf Recovery Area of Apache National Forest in Arizona in 1998. Today, in spite of killings, injuries, and other setbacks (and bolstered by additional releases), the wild population



there is growing. And conflicts are being addressed. In 2014 a group of livestock producers, tribes, environmental groups, and county coalitions developed a "Strategic Mexican Wolf Coexistence Plan" to reduce wolf/livestock conflicts. Their goals are to protect healthy western landscapes, sustain viable ranching, and advance a wild, self-sustaining Mexican gray wolf population. The group's primary strategies include funding for conflict avoidance measures and for depredation compensation. Defenders of Wildlife, a participant in the coalition, has placed remote cameras in remote areas of the White Mountain Apache reservation to monitor the wolves, using payments for photos as an incentive for tribal livestock associations to coexist with the wolves. Today, between 80 and 100 Mexican gray wolves live free in U.S. wildlands.

In Mexico, reintroductions from a captive breeding program began in 2011. A cooperative effort of CONANP, SEMARNAT, Naturalia A.C., CONAFOR, state governments, private ranchers, and others brought the first release of two males and three females near Sierra San Luis. Unfortunately, four of the wolves were killed by poachers or disputants. More recently, another five wolves were released

in Chihuahua. Tracked with telemetry collars, they were still living at the last available report. And last year they produced a litter of pups—the first wild-born Mexican gray wolves in Mexico in more than 30 years!

The challenge to bring this top predator back to viable wild populations is clear, and enormous. The full recovery of Mexican gray wolf populations is not a given. But at least *El lobo* still howls, and as the wolf's role is better understood, more stakeholders are working together to give them wild space. ■

Suggested Readings

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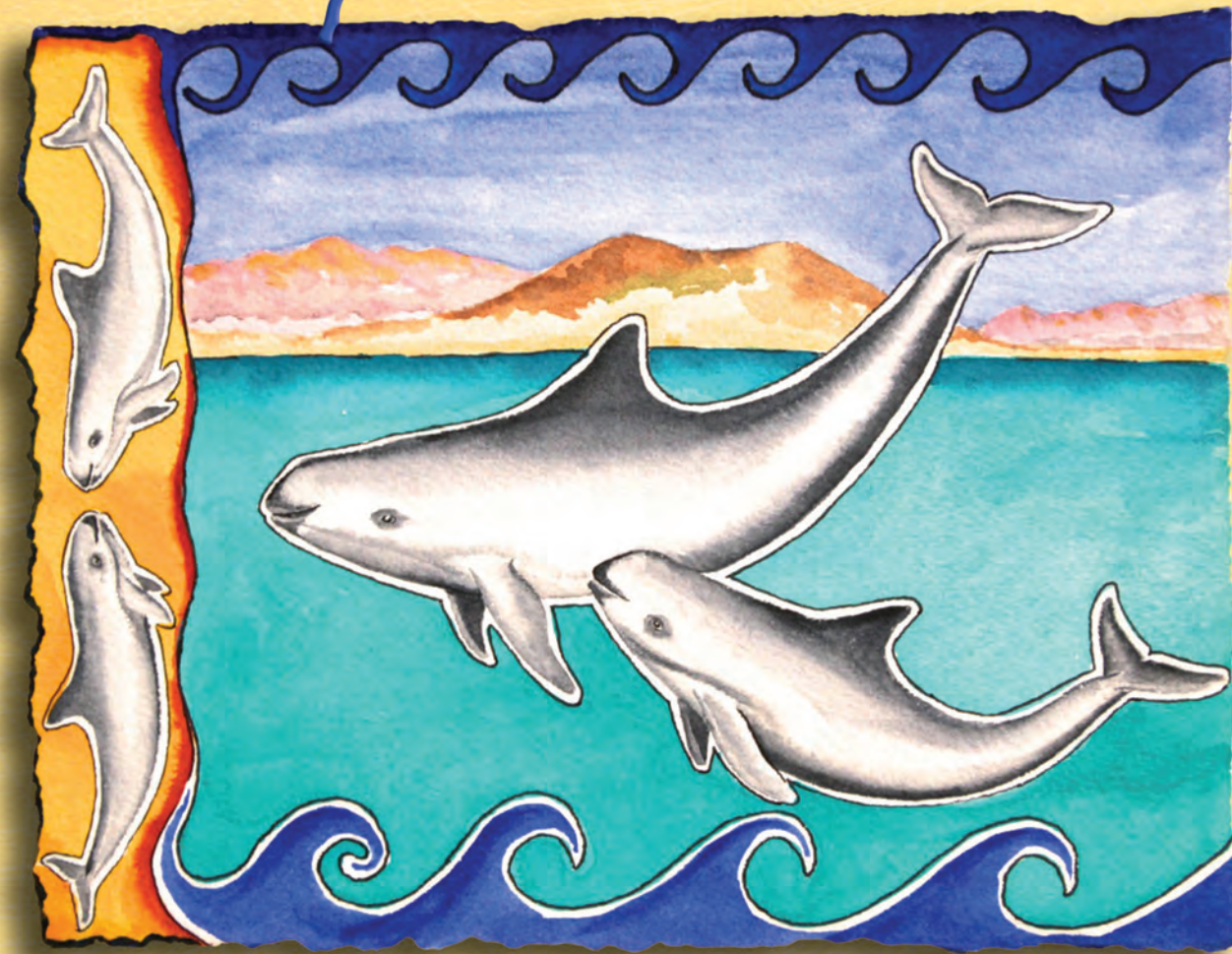
Left to right: Elk (*Cervus canadensis*); jackrabbit (*Lepus timidus*); javelina (*Tayassu tajacu*).

Apex Predators Play a Part

Top predators like jaguars, mountain lions, and wolves prey heavily upon ungulates like deer, elk, and javelina, but also rely upon smaller animals like rabbits, squirrels, mice, reptiles, and amphibians. When they are successful, their populations may increase while the prey populations decrease. With a decreased number of herbivores fewer plants are grazed, thus, the vegetation is apt to become more abundant and more available for other herbivores. When predators are removed, overgrazing by ungulates can prevent reforestation, as with the Caledonian pines in Glenn Affric, Scotland, where wolves were eradicated in the 18th century and red deer populations swelled, scouring the understory year after year. Without corrective intervention (which has begun), when the existing trees died, that old growth forest and all the life it supports would die. Big cats and wolves help sustain the structural integrity of forest, woodland, and other biotic systems. Top predator kills also provide for scavengers and decomposers who make a living from their leavings.

From an evolutionary perspective, over time, these predators shape morphological, physiological, and behavioral adaptations of their prey species. They cull the old and the weak, facilitating the passage of genes from stronger or more cunning animals and shaping adaptations for survival in future populations of the prey species. Since time immemorial, the balance of predators to prey has self-adjusted to sustain healthy functioning habitats. With modern technology, human predators tipped the balance; luckily, we now recognize the need to return top predators to the wild to play their natural part.

Vaquita: Can Mexico's Desert Porpoise Be Saved?



Barbara Taylor, Ph.D., Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanographic and Atmospheric Administration, U.S.,

and

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Although the most endangered marine mammal in the world lives a few hours from Arizona in the northern Gulf of California, it is a creature most Arizonans, and most Americans, have never heard of: it is the vaquita (*Phocoena sinus*). One of seven species of porpoises, the vaquita was first described by scientists in 1958. It has a very limited distribution and has probably always been rare. The vaquita is the smallest of the marine cetaceans (porpoises, dolphins and whales) weighing about 120 pounds. Its black "lipstick and mascara" gives it a Goth look that contrasts with its permanent sweet smile.

Like other porpoises, vaquitas are found in only small groups, averaging two. They don't jump clear of the water and also avoid boats. In fact, they are so hard to see that many fishermen claim they are mythical. No one really knows why they are only found in the shallow (less than 50 m) turbid waters in the far northern Gulf, near the Colorado River Delta. Perhaps their very high frequency echoloca-



photo Carlos Navarro © Omar Vidal



Barbara Taylor



photo Cristian Faez © Omar Vidal



David Starr Jordan



Barbara Taylor

Illustration on page 12: Vaquita in the Gulf of California. Art by Barbara Taylor. This page, clockwise from bottom left: A truck unloads another panga into the bay; vaquitas regularly drown in fishing nets (top left and center images); the NOAA ship at sea; local fisherman with experimental folding fish trap.

tion clicks allow vaquitas to outcompete other dolphins for small squid and fishes, or perhaps the muddy waters allow them to hide from the killer whales and great white sharks that could prey on them.

Entangled Fates

Vaquitas are one of several marine species found only in the northern Gulf of California. Under pressure from fisheries there since the mid-twentieth century, they were first listed as endangered in the United States in 1985, and in Mexico in 1994. Their fate has been linked to another of these endemic species, an endangered fish, the totoaba (*Totoaba macdonaldi*). Both vaquita and totoaba (up to 5 and 6 feet long, respectively) are caught in the same large-mesh gillnets. In the early 1990s, concerns about these accidental deaths in gillnets prompted a study to estimate the number of vaquitas killed. Surprisingly, researchers learned from interviews

with fishermen that vaquitas become entangled and drown in every size of gillnet, including the fine-mesh net used for shrimp, and that about 78 vaquitas were killed in 1993. A survey in 1997 estimated abundance at about 600 individuals, but because the vaquita population can increase at a maximum of only 4% per year, the kill rate was estimated to be at least double what the population could sustain.

Toward Conservation

Although the Government of Mexico created the Upper Gulf of California and Colorado River Delta Biosphere Reserve in 1993 to protect the vaquita, the actual number of fishing nets in the water continued to increase. Mexico then set aside a special Vaquita Refuge in 2005, and in 2008, gillnets were banned in the refuge with financial compensation offered to fisherman to not fish in this area. A survey that same year found that the vaquita population had dwin-

dled to an estimated 250 individuals. The alarming 57% decline in the 11 years since 1997 was consistent with the increased number of gillnets.

Researchers learned from interviews with fishermen that vaquitas become entangled and drown in every size of gillnet, including the fine-mesh net used for shrimp.

Because fishing is the main income for both San Felipe and El Golfo de Santa Clara, fishing methods that will not kill vaquitas are essential for the species to recover. With



Barbara Taylor



R Kessler

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Alejandro Robles

this in mind, Mexico developed a relatively small trawl that can be pulled from artisanal fishing boats, and a regulation was passed that required transitioning to the use of trawls

priate amount has not been possible to date because the fishermen using alternative gear report that they have been actively blocked by the gillnet fishermen.

Since 2001, passive acoustic monitoring has been used to estimate trends in abundance of vaquita. It is based on the simple assumption that the number of echolocation clicks used by vaquitas is correlated with the number of vaquitas. Between 2011 and 2014 the number of clicks declined by 67%! The international recovery team for vaquitas estimate that it is very likely that fewer than 100 vaquitas remain.

Where Have All the Vaquitas Gone?

Although the vaquita population had been steadily declining at about 8 percent per year since about 1993, the

recent dramatic decline almost certainly results from a resurgence of totoaba fishing. In the 1960s, totoaba swim bladders were exported to China for medicinal purposes, supplementing the market for swim bladders from a Chinese fish called the bahaba (*Bababa taipingensis*, now also critically endangered). Both totoaba and vaquitas are illegal to trade under the Convention on International Trade of Endangered Species (CITES). Totoaba trade had disappeared for nearly 20 years after overfishing pushed the fish to the edge of extinction, but resurged as totoaba started to recover in about 2010. Currently, totoaba fishing is still illegal, but due to the exorbitant prices paid for their swim bladders (in May 2015 Greenpeace reported prices ranging from \$5,000 to almost \$65,000 per bladder in Hong Kong) there has since been a rush to harvest them, and vaquitas are dying in those nets now too.

The International Recovery Team for Vaquita—



Courtesy of SEMARNAT



Tom Jefferson



Barbara Taylor



Barbara Taylor



Barbara Taylor

including scientists from Mexico, the United States, United Kingdom, and Norway—sounded the alarm of likely imminent extinction to Mexico's Presidential Commission

It will take decades for vaquitas to recover to levels that would classify the species as endangered rather than critically endangered on the IUCN Redlist.

for the Recovery of Vaquita in 2014. Clearly, the decline caused by the black market totoaba trade called for dras-

tic action, and the Recovery Team called for an emergency gillnet ban. After Mexico announced a two-year ban in December of 2014, there were many months of negotiations to devise a compensation scheme for those affected (fishermen, fish packers, etc.). Enforcement was reported to be at an all time low during this period (see ICUN in Suggested Resources). In April 2015 President Enrique Peña Nieto of Mexico traveled to San Felipe and rolled out the gillnet ban throughout the range of vaquita, charging the Navy with enforcement, including new high-speed enforcement boats. At about the same time, the Sea Shepherd organization (of Whale Wars fame) started a campaign to see firsthand what was happening with vaquita. They photographed the first vaquitas seen in two years (see Suggested Resources) and reported that the new enforcement was keeping waters nearly free of gillnets. Mexico's Department of the Environment is now

funding a survey for a new abundance estimate. That survey is taking place in the fall of 2015.

More to Do

Although the two-year gillnet ban is unprecedented and critical, the ban must be made permanent to save vaquitas. We examined potential threats to vaquitas in 1999 and found that only death in gillnets posed a real threat while contaminants and reduced prey that might result from the loss of Colorado River input were not threats. That analysis remains true today. It will take decades for vaquitas to recover to levels that would classify the species as endangered rather than critically endangered on the IUCN Redlist. The Government of Mexico will be paying \$32 million each year as compensation to fishermen during the 2-year ban, which is unlikely to be a



Clockwise from bottom left: The Mexican government provided high-speed boats to enforce new laws banning gill nets; vaquita friendly shrimp may soon arrive in Southwest markets; Roca Corsaq, a stunning land feature within the Vaquita Refuge .

sustainable solution. These fishermen will need training to use the small trawls for shrimp, and alternative gear will need to be developed for finfish. This transition to new gear will be facilitated if fishermen are paid more for seafood that they catch without using the gillnets that are driving vaquitas to extinction.

Why should we care?

Vaquitas and other species of dolphins and porpoises are beautiful and inspiring to many of us, and have their own inherent value. If we lose vaquitas, it will be the second cetacean to go extinct by the hand of humans (the first being Yangtze River dolphins in 2006). Dolphins

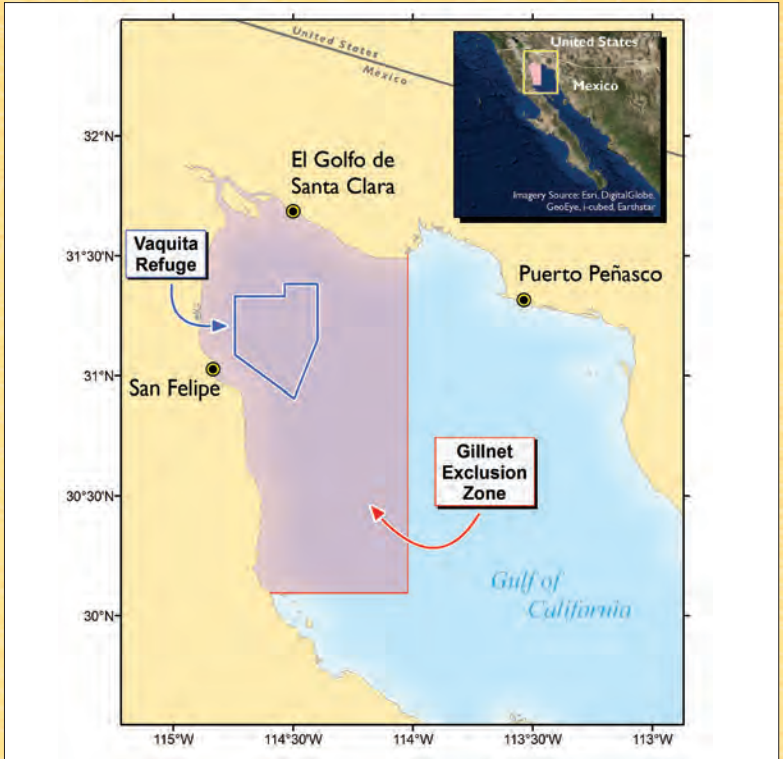
and porpoises that must live in coastal waters drown in gillnets by the hundreds of thousands every year. Mexico could be the first country to solve this problem, leading the world toward fishing practices that won't result in the loss of species.

What can you and I do?

Eat responsibly—know where your food comes from! About 80% of the shrimp caught in the northern Gulf is sold in the United States, and much of it comes from the same gillnets that vaquitas are drowning in. Arizona and California are nearby markets where vaquita-safe seafood can be provided in stores and restaurants. Traceability

and market links that promote a permanent change from current practices to more sustainable ones can provide a future for vaquitas as well as the local fishing communities. But it has to happen soon—the sands of time are running out for the desert porpoise. ■

Look for news on the release of sustainable shrimp from the Gulf of California (Sea of Cortez) on the World Wildlife Fund, Mexico, website this fall or winter: http://wwf.panda.org/who_we_are/wwf_offices/mexico/our_work/. In the meantime, for sources of sustainable shrimp search for Seafood Watch.



Map of the northern Gulf showing the location of the Vaquita Refuge and gillnet exclusion zone

Suggested Readings and Resources

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IUCN. <http://www.iucn-csg.org/index.php/2014/12/07/new-evidence-that-mexican-authorities-are-not-adequately-enforcing-fishing-regulations-to-protect-vaquitas/>.

Sea Shepherd. <http://www.seashepherd.org/news-and-media/2015/04/22/miracle-on-the-water-1684>

Vaquita: Saving the Desert Porpoise. <http://vaquita.tv/video-saving-the-vaquita>



Clockwise from bottom left: Spiny pitar (*Pitar lupanaria*); longarm octopus (*Octopus fitchii*); brown pelican (*Pelecanus occidentalis*) in flight; olive ridley sea turtle hatchling (*Lepidochelys olivacea*).

The Gulf of California is famed for its marine diversity. It harbors more than 5000 species of named invertebrates, nearly 1000 fish, 34 marine mammal, and 5 sea turtle species—and many more unnamed. Terrestrial life from pelicans to bats and human beings find sustenance in it. However, it has been drastically overfished in this century, and residential and commercial development along the coast has knocked the wild breath out of once plentiful and healthy estuaries, places that served as home or critical nurseries for fish, shellfish, birds, and crocodiles. Every species of predatory fish in the gulf is now rare. Sharks are disappearing. And, although conservation efforts have improved the situation since their nadir, especially for the olive ridley, all five sea turtle species are still listed as endangered or threatened. Like vaquita, totoaba face extinction—decimated primarily by fisheries, intentionally, or accidentally as bycatch. Fortunately, there are success stories here as well, for pelicans, whales, and others. (See "Not All Doom and Gloom, page 27). With vigilance and public support, vaquita and totoaba could join them.



TOWARD SPECIES RECOVERY:
THE *Desert Ark* REVISITED

In 1983, Steve Hale, a contract herpetologist, found a dead Tarahumara frog (*Lithobates tarahumarae*) in Sycamore Canyon, a lush riparian area in the Atascosa Mountains, west of Nogales, Arizona. It was the last known individual of its kind in Arizona, the only U.S. state in which it occurred. Fortunately, this species still survived in northern Mexico. Nearly 20 years later, the Arizona Game and Fish Department and U.S. Fish and Wildlife Service collected several hundred tadpoles in Mexico and brought them to the Desert Museum. This early clutch of tadpoles became the founding stock that allowed a reintroduction program to move from possibility to reality.

The Desert Museum, like other accredited zoos and aquariums, carries out research to protect wild species and ecosystems, and uses its facilities and expertise to directly support these activities. The Museum holds species in captivity under programs designed to secure their long-term survival in the wild. It develops procedures for animal care to ensure the health and well-being of species in captivity and to inform wildlife management decisions in the field. The Desert Museum's recent work with threatened and endangered species largely focuses on amphibians, fishes, and reptiles—especially those that are highly dependent on the diminishing aquatic habitats in southern Arizona and northern Sonora. For a number of these threatened or endangered species, the museum directly participates in a specific plan for the recovery of the species. (Two of these are highlighted below.)

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Rhonda Spencer

A species recovery plan spells out the actions and research needed to help those endangered animals (or plants) recover a viable, healthy population. These plans have many parts and take many partners to accomplish. The Desert Museum works as part of large collaborative teams with the Arizona Game and Fish Department, the U.S. Fish and Wildlife Service, public and private landowners, scientists, and other environmental organizations. There are generally seven components of a recovery plan: (1) reducing threats



Jim Rorabaugh, USFWS



Jeff Servoss

Left (pg 18): Tarahumara frog (*Lithobates tarahumarae*). Above left: Tarahumara frog. Above right: American bullfrog (*Lithobates catesbeiana*), nonnative predator and competitor to native aquatic species. Cut out: Lowland Leopard frog (*Rana Yavapaiensis*).

Rhonda Spencer

to existing populations; (2) maintaining, restoring, and creating habitat to be managed long-term; (3) translocating animals to establish, reestablish, or augment populations; (4) building support for recovery efforts through education and outreach; (5) monitoring populations; (6) researching the most effective recovery procedures; (7) applying research and monitoring through adaptive management.

The Desert Museum and other zoos typically help with steps three, four, and six, but some organizations are involved in all aspects of a recovery plan. Zoos also play a major role in educating people about the importance of preserving biodiversity, the status of animals in the wild, and what is being done to help them. In the case of the Desert Museum, we extend this educational mission to endangered plants as well. (The chart on page 21 lists threatened and endangered species currently at the Desert Museum, and the goals for each. Many of the frog species we work with, including the Tarahumara frog and the lowland leopard frog, are not federally listed, and while the Chiricahua leopard frog is a federally listed species, we don't typically keep this species at the Museum; thus, they do not appear on the chart.)

THE RETURN OF THE TARAHUMARA FROG

For over 20 years, the Desert Museum has partnered with the Arizona Game and Fish Department, the U.S. Fish and Wildlife Service, and many other agencies, organizations, and individuals in efforts to breed and repatriate the Tarahumara frog which was extirpated from the United States in the early 1980s. Suspected causes for its decline and disappearance run the gamut from exotic diseases, introduced predators and competitors, and airborne emissions from copper smelters, to drought, flooding, and winter cold.

These greenish-brown frogs can reach up to 4 1/2 inches long; they are highly aquatic, requiring permanent pools of water for their larval and adult stages, and they prefer boulder-strewn streams, seasonal streams with bedrock, and deep, drought-resistant plunge pools. Historically they have been more common in Mexico, ranging into the United States only in the Santa Rita, Tumacacori, Atascosa, and Pajarito Mountains of southeastern Arizona.

In anticipation of the reintroduction effort, the Desert Museum developed a breeding population from tadpoles

collected near Magdalena, Sonora—no small feat, as this species had never been bred in captivity. By using both an indoor fish facility and outdoor enclosures, the Museum substantially increased the area dedicated to tadpole propagation. We fed the tadpoles a diet of frozen collard greens, sliced zucchini, hardboiled egg whites, and algae wafers, which resulted in the rapid development of froglets, shortening the time it took to develop a thriving, self-sustaining captive population.

After several years of successful breeding, hundreds of frogs and tadpoles were released into Big Casa Blanca Canyon in the Santa Rita Mountains in 2004. The repatriated frogs prospered until late 2005, when a catastrophic wildfire exacerbated extreme flooding and sediment deposition in the canyon, severely reducing breeding habitat. Then a large die-off, due to chytridiomycosis—an exotic fungal disease that has accounted for at least a 30% decline in amphibian populations worldwide and a likely cause of the disappearance of the Tarahumara frog in Arizona—further reduced this population in



Bill Radke/USFWS



Jeff Servoss/USFWS



Jeff Servoss/USFWS



Jeff Servoss/USFWS

Left to right: Re-entry site in the Chiricahua Mountains for Chiricahua leopard frogs (*Rana chiricahuensis*); top, Yaqui chub (*Gila purpurea*); bottom, northern Mexican garter snake (*Thamnophis eques megalops*); northern Mexican garter snake.

2007. With this suite of potent ecological challenges, the Big Casa Blanca population all but vanished. Even so, we learned a great deal over the last decade, and biologists still believe that with new strategies repatriation to the United States can succeed. Rather than managing one population in the Santa Rita Mountains the current strategy is to jointly manage three populations in three canyons in the Santa Ritas — Big Casa Blanca, Gardner, and Adobe Canyons—and one population in Sycamore Canyon in the Atascosa Mountains. This strategy also requires more frogs. Toward this end, the Desert Museum has increased its genetic pool of frogs, beginning with tadpoles we collected from Yécora, Sonora, which are now producing young. More than 500 young frogs were released last October. We expect to release the same number every year until the population is self-sustaining, while at the same time biologists work to eliminate the invasive, competitive, and highly predacious bullfrogs.

This new strategy is not without its own challenges. In addition to those faced in the initial repatriation, the canyons of the Santa Rita Mountains contain populations of the fed-

erally threatened Chiricahua leopard frog, and the Atascosa Mountains have populations of Chiricahua and lowland leopard frogs, as well as bullfrogs. Interactions of these ranids will have to be followed closely.

If this new approach works, Tarahumara frogs will have returned to two of their original four historical mountain ranges. The goal is to increase the wild populations to a level robust enough that the frogs will become self-sustaining and no longer require management or protection under the Endangered Species Act.

THE MEXICAN GARTER SNAKE – GOING, GOING, GONE?

Two snakes in two years—that’s what field biologists found in southern Arizona representing an entire population. Though the Mexican garter snake (*Thamnophis eques*) is more common in northern Mexico, this pair (and a handful more that came in afterwards) was all that was available for the Desert Museum to establish a breeding group for the Empire Cienega population. It is a species that had never bred in captivity before.

The Desert Museum’s garter snake recovery work began in 2006 with several of the same public partners we worked with for Tarahumara frog recovery, while others, such as Northern Arizona University, Arizona State University, and the Phoenix Zoo, also joined the effort.

Although we didn’t have much to start with, nature and lots of nurture (with a measure of good fortune) combined to raise these animals to breeding size, leading to the birth of the first captive-born baby Mexican garter snakes. Now, well over 100 snakes have been produced, all of which have been or will be released into the wild (or maintained as a captive assurance colony) in a collaborative effort to keep this threatened species from slipping into endangered status. The Desert Museum released 19 Mexican garter snakes earlier this year, and we still have 10 young snakes to release.

The Mexican garter snake recovery program may soon shift from simply replenishing the wild to field research wherein released animals are implanted with transmitters, allowing biologists to track them and see how they assimilate to their natural habitat.

Above: Narrow-headed garter snake (*Thamnophis rufipunctatus*), a threatened species.

INTO THE FUTURE

The Arizona-Sonora Desert Museum, along with many zoos and aquariums, is actively engaged in saving the great web of life. We focus both on habitats and species at risk of extinction—from the thick-billed parrot to the ocelot and Pima pineapple cactus. As noted above, we developed housing and husbandry methods for ranid frogs (leopard frogs and their relatives) that accelerated and maximized development of tadpoles and froglets in a semi-natural captive environment, producing more healthy animals for wild release. We were the first to produce Tarahumara frogs and Mexican garter snakes in captivity. Our techniques have been shared with and adopted by partner organizations in recovery efforts. We are currently working on breeding techniques for the Sonoyta mud turtle, an at-risk species that has never been bred in captivity, and are collaborating on captive propagation of Yaqui catfish, another at-risk species. Not every effort has been successful, but with each species we gained knowledge and have contributed to improved chances for their survival. ■

Suggested Resource

Association of Zoos and Aquariums Reintroduction Programs: <https://www.aza.org/reintroduction-programs/>

ENDANGERED, THREATENED AND CANDIDATE SPECIES AT ASDM

x denotes ASDM goals for each species

SPECIES	Assurance Population	Breeding	Release/Return to Wild	Exhibit/Education
Endangered				
Sonoyta pupfish	x	x	x	x
bonytail chub				x
humpback chub				x
Yaqui chub	x	x	x	x
Colorado pikeminnow				x
razorback sucker				x
Gila topminnow	x	x		x
Yaqui topminnow	x	x	x	x
Sonoran tiger salamander				x
San Esteban chuckwalla		x		x
Santa Catalina Island rattlesnake		AZA collaborative		x
thick-billed parrot		AZA collaborative		x
Mexican gray wolf		outside ASDM	x	x
ocelot		x		x
Nichol’s Turk’s head cactus				x
Arizona hedgehog cactus				x
Pima pineapple cactus	x		x	x
Huachuca water umbel				x
Kearny blue star				x
Threatened				
Apache trout				x
Sonora chub	x	x		
Beautiful shiner	x	x		x
Yaqui catfish	x	x		x
Mexican garter snake	x	x	x	
New Mexico ridgenose rattlesnake	x (multiple institutions)	x		
Candidate				
Gila chub	x	x	x	
Sonoran Desert tortoise				x
Sonoyta mud turtle	x	x	x	



FROM AN **Owl Flap**
TO LANDSCAPE CONSERVATION:
The Sonoran Desert Conservation Plan

In 1997, the U. S. Fish and Wildlife Service listed the cactus ferruginous pygmy owl (*Glaucidium brasilianum cactorum*) as an endangered species under the Endangered Species Act. That listing, and the uncertainty surrounding its impact on development activities, sent shockwaves through the development community in Pima County. This kind of reaction was not unique, because when a species is added to the federal endangered species list, a typical response is for the government to develop regulations and guidelines specific to the species of interest, and the subsequent restrictions have historically prevented or severely impacted many residential or commercial development opportunities. Yet the story of Pima County's response is not typical.

Pima County recognized that because our region is a "hotspot" of biological diversity, it needed to take a more creative and comprehensive approach, one that accommodated both the county's economic foundation and the health of the natural environment that supports wildlife, tourism, and quality of life for its residents. As early as the 1970s, widespread public concern over the loss of open space to development had already led to tensions between those who were pro-development and those who were seeking to save certain areas from environmental loss. Development interests prevailed most of the time. By 1997, it was clear that high biodiversity and rapid growth would lead to further listings, and knowing that its citizens were demanding a proactive approach to natural resource conservation, Pima County embarked on an environmental planning process unprecedented for a local government in the United States at that time. This new plan, which became known as the

Sonoran Desert Conservation Plan (SDCP), aimed to balance conservation needs of species while providing a stable set of regulations for development interests. Acting on behalf of the Pima County Board of Supervisors, the late Dr. Maeveen Marie Behan led a vigorous community dialogue to address the conservation needs of the tiny owl; she also facilitated dialogue embracing growth issues, wildlife and ecosystem functional characteristics, cultural values, and the constraints of water resources.

In response, the bipartisan board indicated their willingness to use emerging scientific information to guide land-use decisions for the protection of sensitive habitats for a range of plants, invertebrates, and wildlife, including the pygmy owl. Yet economic concerns were critical, and they wanted to know how to maintain the tax base while also placing value on the "natural capital" that ultimately supports the economy. In response, Pima County completed an economic analysis, which showed the densest development had the greatest benefits to the tax base and used the least amount of land, while, by contrast, some types of low-density development in more remote areas were proving expensive to maintain and were more harmful to species that were—or were likely to be—listed under the

Endangered Species Act (ESA). Behan oversaw the production of over 200 individual studies by scientists and experts in subjects as diverse as invasive species, water quality, and taxation. The process also included more than 600 public meetings to educate and gain input from the public.

The Sonoran Desert Conservation Plan was officially approved by the board in 2001. Its adoption provided a foundation for a new, more holistic approach for how the county addresses a range of resources such as critical habitats and biological corridors, riparian areas, mountain parks, and historical, ranch, and cultural preservation.

Despite the county's efforts to address the specific needs of individual species, the pygmy owl provides an important lesson for the limits of the county's actions and influence. Since 1999, populations of the owl in Pima County have declined significantly. They currently occur in very low numbers in the Altar Valley and on the Tohono O'odham Nation, but are now absent from northwest Tucson and Marana, which was the center of controversy for the owl. The cause of the owl's decline in Arizona is not known for certain, although a long-term study by Aaron Fleisch, research specialist at the University of Arizona's School of Natural Resources and the Environment, of the closest core

population of owls in northern Sonora, Mexico, shows the recent drought has negatively affected that population. The owl was removed from protection under the ESA in 2007 due to a re-evaluation by the USFWS. Yet the owl remains at risk—in part due to buffelgrass invasion and associated fires, and in part due to loss of suitable habitat.

Page 22: Cactus ferruginous pygmy owl (*Glaucidium brasilianum cactorum*).
Below: Sonoran desert tortoise (*Gopherus agassizii*).
Bottom: Rancho Seco.



Brian Powell
and **Julia Fonseca**,
Pima County Office
of Sustainability and Conservation

Aaron Fleisch

Brian F. Powell



Brian F. Powell



Brian F. Powell

CONSERVING LAND, CONSERVING ECOSYSTEMS

Pima County has long placed an emphasis on land acquisition for the protection of species and ecosystem function. In the 1980s and '90s, the county acquired conservation lands to protect Cienega Creek, one of the last perennial streams in Pima County and home to towering cottonwood and willow riparian forests and threatened and endangered species such as the Gila topminnow, yellow-billed cuckoo, and Mexican garter snake.

While these early acquisitions were important steps, it was the voter-approved 2004 bonds that initiated a new era for Pima County. Those bonds helped to steer what was a booming housing market away from treasured places such as the Canoa Ranch, Painted Hills, and Tumamoc Hill. The bond money also established a ranch conservation program to preserve working landscapes in the Altar, San Pedro, and Cienega Valleys, including the A-7 and Six Bar (San Pedro River Valley) and the Rancho Seco and Diamond Bell (Altar Valley). Collectively, these lands harbor representative habitat of all the species covered by the Multi-Species Conservation Plan.

MULTI-SPECIES CONSERVATION PLAN

The conservation actions by Pima County have positioned it to receive a special permit recognizing voter-approved land acquisitions as mitigation for future impacts to threatened and endangered species habitat. This permit, issued by the Fish and Wildlife Service (USFWS), will allow the county and a portion of its regulated development community to lawfully harm or destroy (known as “take”) threatened and endangered species and their habitat, provided the take is the result of otherwise lawful activities and provided that Pima County continues to rely on the adopted conservation measures to avoid, minimize, and mitigate the proposed impacts. After considerable public review and input, the permit, also known as the Multi-Species Conservation Plan (MSCP), is close to being finalized by the USFWS.

The County’s MSCP permit addresses 44 species, including the Tumamoc globeberry, lesser long-nosed bat, Merriam’s mouse, burrowing owl, yellow-billed cuckoo, Gila topminnow, Sonoran Desert tortoise, northern Mexican garter snake, and dozens of other plants and animals (see chart, next page). Nine species on the permit are currently listed as threatened or endangered under the ESA, and an additional three species are candidates or have been petitioned for listing. The remaining species are included based on their potential to be listed during the permit’s 30-year period.

Top left: Six Bar Ranch. Left: Tucson Mountain Park.

A required element of the MSCP will be mitigation, which compensates for the loss of habitat in one area in exchange for protection of land elsewhere. Under the MSCP, the amount of conservation land needed to compensate for takings varies depending on the location of the disturbance and its relative biological importance as gauged by a Conservation Land System map (see sidebar page 26). For example, for land in a Biological Core Area, five acres of land will be preserved in exchange for every one acre of land disturbed. The MSCP permit will assure long-term protection of county-owned parks and conservation lands that are used as mitigation lands. Pima County will incrementally protect these lands using legal instruments such as conservation easements and covenants. Legal protection would have the benefit of protecting these parks and natural areas from being sold or re-purposed to other uses in the future.

BACK TO THE FUTURE

Ten years have passed since the original bond-funded land acquisitions, and Pima County has—or soon will have—approximately 71,000 acres of deeded land for the purpose of long-term conservation under the ESA, in addition to holding grazing leases on approximately 124,000 acres of State and Federal lands. These conservation commitments are joined with other open-space lands such as Tucson Mountain Park to create a total of over 240,000 acres of county-managed preserves. If Pima County voters approved the natural open space question in the November bond election, the bond funds will be used to purchase additional lands that will provide the county with all of the MSCP’s anticipated mitigation needs for the permit.

The government of Pima County has long recognized that residents of the greater Sonoran Desert Region take pride in its natural beauty and diversity; they are hallmarks of our sense of place and community. The MSCP component of the Sonoran Desert Conservation Plan is the just latest of the county’s many initiatives to promote more sustainable economic growth in tandem with conservation of our natural and cultural treasures.

SUGGESTED RESOURCES

See: http://webcms.pima.gov/government/sustainability_and_conservation/conservation_science/the_sonoran_desert_conservation_plan/

Top right: Cienega Creek Natural Preserve. Right: Pima pineapple cactus (*Coryphantha scheeri* var. *robustispina*).

SPECIES COVERED UNDER THE MULTI-SPECIES CONSERVATION PLAN

- Pima pineapple cactus**, *Coryphantha scheeri* var. *robustispina*
- Needle-spined pineapple cactus**, *Echinomastus erectocentrus* var. *erectocentrus*
- Huachuca water umbel**, *Lilaeopsis schaffneriana recurve*
- Tumamoc globeberry**, *Tumamoca macdougalii*
- Mexican long-tongued bat**, *Choeronycteris mexicana*
- Western red bat**, *Lasiurus blossevillii*
- Western yellow bat**, *Lasiurus xanthinus*
- Lesser long-nosed bat**, *Leptonycteris curasoae yerbabuena*
- California leaf-nosed bat**, *Macrotus californicus*
- Pale Townsend’s big-eared bat**, *Plecotus townsendii pallescens*
- Merriam’s mouse**, *Peromyscus merriami*
- Western burrowing owl**, *Athene cunicularia hypugaea*
- Cactus ferruginous pygmy-owl**, *Glaucidium brasilianum cactorum*
- Rufous-winged sparrow**, *Aimophila carpalis*
- Swainson’s hawk**, *Buteo swainsoni*
- Yellow-billed cuckoo**, *Coccyzus americanus*
- Southwestern willow flycatcher**, *Empidonax traillii extimus*
- Abert’s towhee**, *Melospiza aberti*
- Bell’s vireo**, *Vireo bellii arizonae*
- Longfin dace**, *Agosia chrysogaster*
- Desert sucker**, *Catostomus darki*
- Sonora sucker**, *Catostomus insignis*
- Gila chub**, *Gila intermedia*
- Gila topminnow**, *Poeciliopsis occidentalis occidentalis*
- Chiricahua leopard frog**, *Lithobates chiricahuensis*
- Lowland leopard frog**, *Lithobates yavapaiensis*
- Desert box turtle**, *Terrapene ornata luteola*
- Sonoran desert tortoise**, *Gopherus morafkai*
- Tucson shovel-nosed snake**, *Chionactis occipitalis klauberi*
- Northern Mexican garter snake**, *Thamnophis eques megalops*
- Giant spotted whiptail**, *Aspidoscelis stictogramma*
- Ground snake (valley form)**, *Sonora semiannulata*
- San Xavier talus snail**, *Sonorella eremita*
- Talus snail (11 species)**, *Sonorella* spp.



Terry Hendricks



Hes Rouden

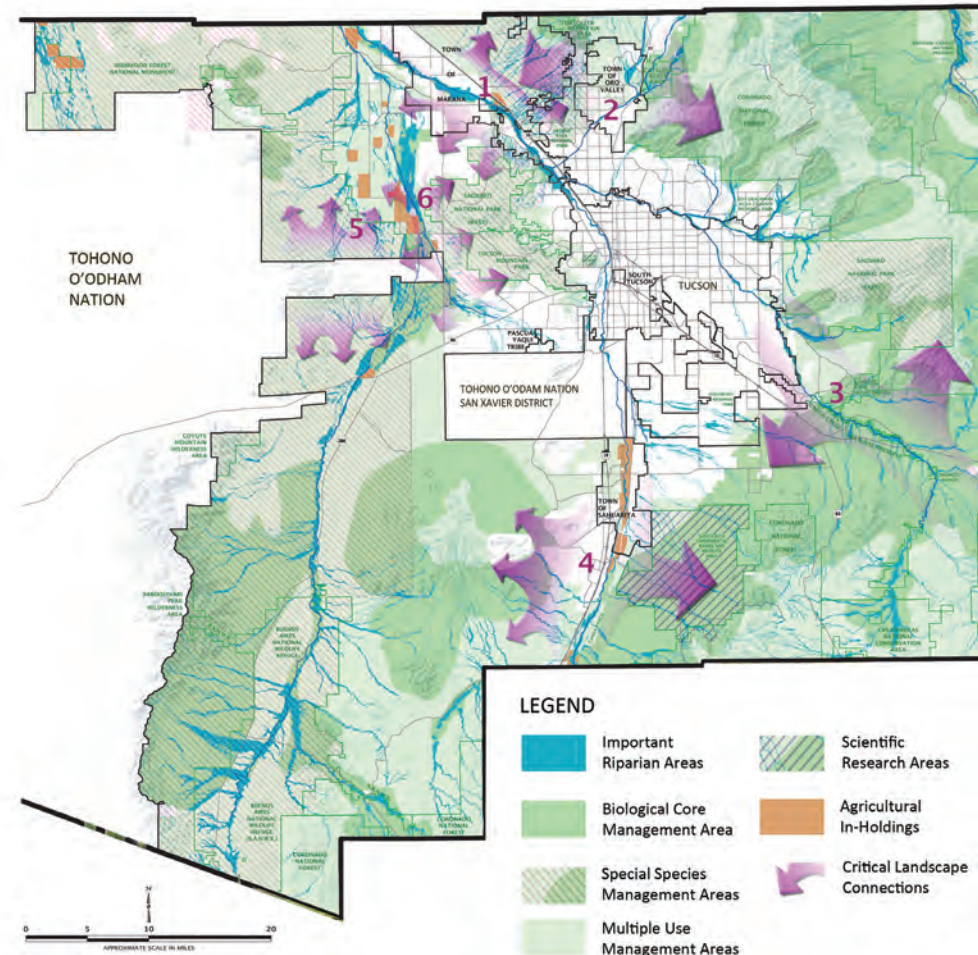
THE MAEVEEN MARIE BEHAN CONSERVATION LAND SYSTEM MAP

Pima County adopted the Conservation Land System (CLS) map in 2001. It is the culmination of a detailed analysis by local scientists of the county's rich biological resources and their threats. The CLS map integrates these elements to characterize land according to its relative biological importance, and it's a map with powerful implications. It is applied to rezoning decisions by the County Board of Supervisors, which can require developers to set aside between 66 and 95 percent of land as undeveloped open space, depending on its location within the CLS. In addition, the CLS map has influenced investments in regional roadways and sewage treatment. It has also been used to guide acquisitions made with voter-approved bonds for habitat protection. Pima County is unusual, if not unique, in using an explicit biological foundation for making discretionary land-use decisions.

THE MAEVEEN MARIE BEHAN CONSERVATION LAND SYSTEM PRIORITY BIOLOGICAL RESOURCES OF THE SONORAN DESERT CONSERVATION PLAN

The map on this page shows Pima County east of the greater Tohono O'odham Nation. For a full view of the map, including all of Pima County, as well as definitions of the key resource assignments, see the map link at <http://webcms.pima.gov/cms/one.aspx?portalId=169&pageId=53493>.

The Critical Landscape Connections noted are: (1) across the I-10/Santa Cruz River corridors in the northwest; (2) between the Catalina and Tortolita Mountains; (3) across the I-10 corridor along Cienega Creek in the east; (4) across the I-19 and Santa Cruz River corridors in southern Pima County; (5) across the Garcia strip extension of the Tohono O'odham Nation; and (6) across the Central Arizona Project canal in Avra Valley. Critical Landscape Connections are broadly defined as areas that provide connectivity for movement of native biological resources but which also contain potential or existing barriers that tend to isolate major conservation areas.



PLANTS

Spurred by the Association of Zoos and Aquariums's SAFE (Saving Animals From Extinction) program, we have focused on charismatic animals at risk in this *Sonorensis*, but the loss of species in the plant kingdom is equally critical. Plant communities are intricately woven in, and essential to, the lives of all animals; they translate the sun into consumable nutrients (food), provide shelter, and root and replenish the soil.

Although it is unclear if a few plant species of the Sonoran Desert that have been presumed extinct actually are gone forever, in Arizona 14 plants are listed as endangered, another 7 threatened—from Welsh's milkweed and Canelo Hill's ladies tresses to the Arizona cliffrose. Across the Sonoran Desert Region there are undoubtedly more.

You can see several endangered plants on ASDM grounds, including the Pima pineapple cactus, Kearny's blue star, Huachuca water umbel, and Nichol's Turk's head, Arizona hedgehog, and Acuña cactuses. ASDM also partners with public agencies on conservation programs for some endangered species. One of the target species for Pima County's Sonoran Desert Conservation Plan, the Pima pineapple cactus is being grown out at the Desert Museum for distribution. It has been crowded out of its range out by urbanization, mining, overgrazing, and competition with native grasses. As a riparian obligate, Huachuca water umbel populations diminish as our rivers dry. The Desert Museum has 27 clones of the water umbel in reserve for the US Fish and Wildlife Service in the event wild populations disappear. We are currently partnering in research on the pollination of Kearny's blue star. Pima County also has a native plant nursery where they grow out targeted plant species for conversation lands.

As with animals, the protection of individual species is problematic since their survival is deeply entangled with the whole ecological community. It is also logistically complex, and the use of cultivated populations in green houses and gardens is only effective in limited situations. It is conservation of lands and connectivity that will prevent the collapse of both species and, eventually, whole ecosystems. Saving endangered plants in habitat will be to our benefit and to the benefit of all the other two, four, six, eight, or multi-legged residents of the Sonoran Desert Region—pollinators, herbivores, carnivores, and omnivores alike!!

If you want to learn more or get involved, several other organizations work to encourage the appreciation of native plants and/or the protection of plants at risk in this region: the Arizona Native Plant Society, US Fish and Wildlife Service, The Nature Conservancy, Center for Biological Diversity, Tucson Cactus and Succulent Society, and regional botanical gardens.

ASDM Botany Staff



NOT JUST DOOM AND GLOOM: Bright Lights IN CONSERVATION

Rodrigo A. Medellín, Ph.D., Senior Professor of Ecology, National Autonomous University of Mexico, and Past President, Society for Conservation Biology.

Brown pelican (*Pelecanus occidentalis*) in flight.

When we find articles about conservation in the news—on the internet or other media—they are almost always negative. From elephants being massacred to an orphan rhino nudging his dead, de-horned mom, everything looks grim. But there are many stories that are much more positive, even inspirational—stories that give us hope that, indeed, good things ARE happening in the world. These stories are the result of the tireless work of lots of great people working every day, very hard, very effectively, who are rarely seen in the media. Here, I will tell you a few of these stories.

OLIVE RIDLEY SEA TURTLES

The oceans have sustained bountiful populations of myriad species over eons—sea turtles among them. These reptiles, like other marine species, suffered catastrophic declines, primarily from the 1940s through the 1970s. Although several species still face a grim situation, olive ridley sea turtles (*Lepidochelys olivacea*) provide us with an inspirational story that shows how good management resulting from collaboration among local residents, dedicated scientists, and responsible government personnel really can save a species.

In the mid-twentieth century, an estimated 10 million olive ridley turtles were nesting along the Pacific coast of Mexico. These solitary turtles inhabit the open ocean, migrating hundreds or even thousands of miles annually, congregating in groups only at their specific nesting grounds to lay eggs. But in the 1960s several countries across the turtle's range opened fisheries for these marine reptiles, which were easily harvested for their meat and eggs, and the entire population of olive ridleys quickly crashed. This tragedy did not go unnoticed, and in the 1970s an outcry from the public and warnings from scientists pressed governments and international organizations to move to stop the unsustainable consumption of sea turtles, to begin protecting their nesting beaches, and to ban their irrational slaughter. Surprisingly fast, olive ridley turtles began recovering. So much so, that a single nesting beach in Mexico that had plummeted to a mere 50,000 nests in 1988 recovered more than ten-fold to 700,000 nests in 1994, and well over 1,000,000 in 2000. Although eggs and hatchlings suffer severe natural predation, with typically less than 1% reaching maturity, counts of males and females in the ocean by that time indicated an estimated population of 1,000,000 turtles

just along that one beach. Unless some unforeseen catastrophic factor comes into play, we expect the recovery of the olive ridley to follow a sure and steady course.

On the beaches of the Ostional Wildlife Reserve, created on the Costa Rican Pacific coast in the early 1980s, an estimated ten million eggs are laid by hundreds of thousands of turtles almost every month of the year. With so many turtles, there is no room for all the nests, so turtles digging nests in the later days of the *arribada* (the mass egg-laying seasons, literally meaning "arrival") would unintentionally dig out many earlier-placed nests. So in an unprecedented alliance, local communities, scientists, and authorities agreed to allow harvesting of eggs from the early nests of every *arribada*, which provides income to the community and galvanizes their commitment for sea turtle conservation. Among other things, no glaring lights and no large buildings are allowed in the town of Ostional, to prevent the turtles from becoming become disoriented.

BROWN PELICANS

Next time you are on a beach, anywhere from Puerto Vallarta to Seattle or from Cancun to Atlantic City, try to imag



Joost van Uffelen



USFWS



Juan M. Riquelme-Baron 2012 (<http://myd.as/p6362>)



Andreas DiGiulio



Rodrigo Medellín



Francisco Abarca

Above left: Olive ridley sea turtle (*Lepidochelys olivacea*). Above middle: Sea turtle nest relocation. Above right: Hatching neonates of olive ridley sea turtles south of Baja California Peninsula. Page 29 above left: Lesser long-nosed bat (*Leptonycteris yerbabuena*) babies in cave roost at El Pinacate reserve. Above middle: Rodrigo A. Medellín in the field with students and bats in Mexico. Cut out page 29: Brown pelican (*Pelecanus occidentalis*).

Above right: In April 2015, conservation leaders from three countries gathered to sign on to the North American Bat Conservation Alliance. In the photo, sitting, from left: Sue Milburn-Hopwood, Director General, Canadian Wildlife Service; Dan Ashe, Director, U.S. Fish & Wildlife Service; Jorge Maksabedian de la Roquette, Director General, Dirección General de Vida Silvestre, SEMARNAT. Standing, from left: Basile Van Havre, Director of Population Conservation and Management, Canadian Wildlife Service; Rodrigo A. Medellín, Mexico leader, North American Bat Conservation Alliance (NABCA); Charles Francis, Canada leader, NABCA. Jeremy Coleman, the U.S. leader of NABCA was not present.

ine what you see minus brown pelicans (*Pelecanus occidentalis*). As implausible as it may seem, that was the grim prediction of one conservation champion of the mid-twentieth century (and a personal hero of mine). Born in 1907, Rachel Carson grew up to be an accomplished scientist and naturalist. In 1962, with her book *Silent Spring*, she warned of the terrible, pernicious effects of certain pesticides that were being indiscriminately applied across the United States and elsewhere. Her predictions almost came true, and might have without her warnings. By that time, brown pelicans and many other bird species were suffering from an environmental side effect of DDT that caused eggshells to be extremely thin and brittle. The thin shells were severely hampering reproduction, because when the female laid an egg it would immediately break or, in the case of brown pelicans, the weight of normal incubation activities would crush the fragile egg before it hatched.

Stories abound of collapsed bird populations, including bald eagles, peregrine falcons and other raptors, but brown pelicans were hit especially severely. In the late 1950s and 60s, for example, an estimated 2,000 pairs of California brown pelicans (*P. occidentalis californicus*) nested on California's Channel Islands alone. Only ten years later,

most reports from the islands described complete reproductive failure; not a single egg hatched. For example, out of 552 nests in Anacapa Island in 1970, a single fledging was produced. Fortunately, thanks to the evidence compiled by Carson and the efforts of many other allies, the use of DDT was banned in 1972, and in a relatively short period of time, the pelican populations stopped declining and began to climb. Today, just along the west coast of Mexico and California, an estimated 48,000 pairs breed each year, with successful hatching. *Pelecanus occidentalis* is not out of dire straits yet, but its recovery is robust.

In Louisiana, where the brown pelican is the official state bird, its population had been completely obliterated by the pesticides by 1963, but after an early and vigorous reintroduction program, the population grows bigger every year. Since 1988, the International Union for Conservation of Nature's Red List has categorized the brown pelican as "Least Concern," and the California brown pelican was delisted under the U.S. Endangered Species Act (ESA) in 2009. Inspiring leaders such as Rachel Carson have the power to change the world, using solid evidence, careful observation, unbiased analysis, strong conviction, and the energy to embark on the battle.

LESSER LONG-NOSED BAT

In the early 1980s I was invited to join an expedition to central and northern Mexico directed by Don Wilson of the Smithsonian Institution. Its focus was to document the status of the Mexican and lesser long-nosed bats of the region—bats in the genus *Leptonycteris*. It did not take long, less than two years, to realize that many of the colonies that had once been reported with thousands of bats showed precipitous declines. This evidence, and declining populations of these two bat species in the United States, prompted the U.S. Fish and Wildlife Service to list both species as endangered in 1988; a few years later, in 1994, Mexico followed suit, listing them as threatened.

In 1994, with both species listed in both countries, we—myself and others in partnership with the University of Mexico and Bat Conservation International—created the Program for Conservation of Bats of Mexico, and promptly began a three-pronged strategy for the bats' recovery: conservation-driven research; strong environmental education directed at the people living in the vicinity of key caves where the bats mate or give birth to their pups; and specific conservation actions in cooperation with all levels of government, local communities, and other stakeholders.

This work took us to many states of Mexico, from the extreme south in Chiapas to the extreme north in Sonora. We provided both school children and adults with the facts about lesser long-nosed bats, improving their image, letting them know how important bats are for pollination of cacti, agaves, and other plants. Quickly, residents of the local communities became allies and defenders of the bats. Pollination of the blue agave, the only source of tequila, is a huge service of these migrating bats. But the cloning of these agaves in large-scale commerce has been cutting down the bats' migratory nectar resources, while making agave populations weaker from lack of genetic diversity. So we are working with the agave industry as well.

Little by little at first, but then faster and faster, all the *Leptonycteris* colonies monitored over 10 years (13 colonies in 8 states of Mexico) showed stability or growth. Some new colonies even appeared. Early in 2015, twenty years after beginning our program, we were able to announce jointly with the Mexican federal government, that the lesser long-nosed bat had recovered. This represents the first time a species has been removed from the Mexican Endangered Species list due to a recovery program in Mexico. Today, the healthy bat populations provide essential ecosystem services.

THE OUTLOOK

This past April, due to the work of a dedicated group of conservation leaders, who I have been working closely with for a nearly a decade, Mexico, the United States, and Canada signed on to the North American Bat Conservation Alliance. More successes will certainly come. Along with the benefits—beyond important pollination services, bats also provide pest control estimated at no less than \$3 billion per year in the U.S. alone. The indefatigable work of many scientists, educators, local landowners, and government agencies consistently prove that collaboration is the key to species recovery.

There are many other stories of conservation successes, of course. A recent article in *Trends in Ecology and Evolution* indicates that of 92 species of marine mammals included in one population trend analysis (of a total 128 marine mammal species), 42% are increasing, only 10% are decreasing, and the remainder are stable, which likely indicates they may also be recovering. For example, while still at risk in some areas, the charismatic gray whale (*Eschrichtius robustus*) has strongly rebounded from the brink of extinction. With regulations banning DDT, bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco*

peregrinus), whose populations were also decimated in the mid-twentieth century, have been delisted under the ESA. With the concerted efforts of conservation champions and forward-thinking government staff, and with public support, we can bring about more positive narratives—including, perhaps, the highly threatened vaquita porpoise, monarch butterfly, Mexican gray wolf, jaguar, and a suite of fishes, amphibians, reptiles, and plants. ■



Angella Sorensen

Suggested Resources

Natural World: The Bat Man of Mexico. Episode 6 of 10. BBC, 2014-2015.

Sonorensis: Celebrating Bats, ASDM, 2011

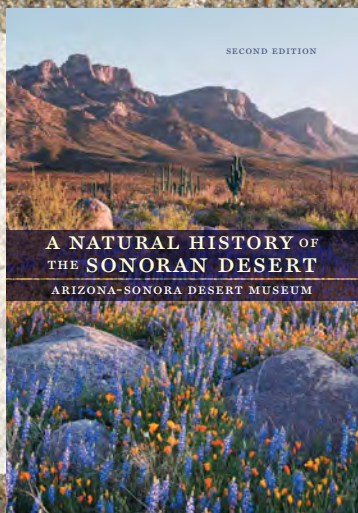
http://www.allaboutbirds.org/guide/brown_pelican/lifehistory

<http://www.nmfs.noaa.gov/pr/species/turtles/oliveridley.htm>



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