



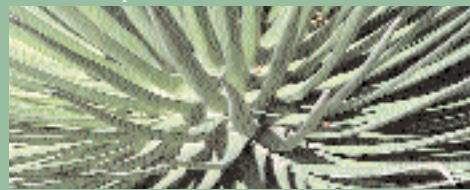
sonorensis
ARIZONA SONORA DESERT MUSEUM

BIOINVADERS

BIOINVADERS of the Sonoran Desert

Where did they come from? Why are they such a serious threat? Can anything be done to control them?





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CONTENTS

- 1 Introduction
- 3 Exotic Species: An Introduction
Native Species: An Epitaph
by Gary Paul Nabhan
- 6 Controlling Invasive Exotics—
The Right Tool for the Job
by Barbara Tellman
- 7 *Salvinia molesta*—A Growing Threat
to Arizona's Waterways
by Barbara Tellman
- 8 Bullfrogs—The Dinner Guests
We're Sorry We Invited!
by Cecil Schwalbe and Phil Rosen
- 11 The Conservation Dilemma of
Non-native Versus Native Fishes
by W. L. Minckley
- 14 The Sonoran Desert's
Ten Least Wanted
- 16 Plant Stories of the Sonoran Desert
by Peter Gierlach
- 18 Battling Buffelgrass:
You Can't Win If You Don't Play
by Sue Rutman
- 21 Red Brome and Wildfires
by Jerry Asher
- 22 Pulling Together: The Desert
Museum Battles a Biological
Wildfire
by Patty West and Barb Skye
- 24 Invasive Plant Management
in the Sonoran Desert: An Update
by Nina Chambers, John A. Hall, and Barb Skye
- 26 Exotic Grasses and
Native Wildlife
by Jane H. Bock and Carl E. Bock
- 28 What Can You Do?



T. R. VanDyke

Red brome

Introduction

Exotic. Non-native. Alien. These are just a few of the terms that have been applied to the approximately 30,000 foreign plants, animals and microbes that have taken up residence in the United States since Europeans first set foot on her shores. Many of these introduced species have caused little harm; others have caused irreparable damage, displacing native plants and animals and disrupting entire ecosystems. The term "invasive species" is used to differentiate the latter group.

How serious is the problem? A study published in 1998 by *BioScience* magazine reports that invasive species constitute a greater threat to endangered species than do pollution, overharvesting, and disease combined; only habitat loss ranks higher. Invasive plants, for example, now infest over 100

million acres in the United States. Three million acres, an area twice the size of Delaware, is lost to these invasive plants each year.

Unlike the kudzu-draped forests in southeastern United States, invasive species in the Sonoran Desert are less apparent to the untrained eye. Unfortunately they are just as damaging to biodiversity and ecosystem processes. This special edition of *sonorensis* updates some of the information provided in the winter 1999 Bioinvaders issue of *sonorensis*, which took a close-up look at how the invasive species problem is manifesting itself in the Sonoran Desert along with potential solutions.

To achieve success in the war against invasive species, we must make use of all the tools available to us, such as public policy reform, public awareness programs, and

environmentally friendly control methods. Most importantly, we must form collaborative, inclusive partnerships that can effectively and efficiently coordinate responses to a common threat. The joint production of this publication by our respective organizations represents one such partnership.



Richard H. Daley
CEO and President
Arizona-Sonora Desert Museum

Patrick Graham
Arizona State Director
The Nature Conservancy

Luther Propst
Executive Director
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Sahara mustard



John Waters



Even remote areas, such as the floor of MacDougal Crater, near the western flanks of the Sierra Pinacate, are not safe from invasive species.



View of a 1994 fire burning in Saguaro National Park. Red brome was probably the primary culprit.

“Having recently passed the great age of biogeography, we will have entered the age after biogeography, in that virtually everything will live virtually everywhere, though the list of species that constitute ‘everything’ will be small. . . . Earth will be a different sort of place—soon, in just five or six human generations. My label for that place, that time, that unavoidable prospect, is the Planet of Weeds.”

David Quammen
Harper’s Magazine (1998)

Gary Paul Nabhan
former Director of Conservation and Science
Arizona-Sonora Desert Museum

If you climb Camelback Mountain in Phoenix, then “A” Mountain in Tucson, then the hills behind “Sandy Beach” at Cholla Bay, Sonora, you will meet some of the same stragglers in all three places—plants and animals which did not occur in the Sonoran Desert a century ago. Africanized bees may buzz around your head, or try to suck up the last bit of moisture in your coffee cup. At your feet, and in your socks, you will find the seeds of several exotic grasses and mustards. Sahara mustard. Red brome. Buffelgrass, or its ornamental kin, fountain grass. These relative newcomers to the Sonoran Desert can be found in nearby protected areas as well, from the Pinacate Biosphere Reserve, to Saguaro National Park, to the Sierra Bacha, home of the “boojums” on the Sonoran coast of the Gulf of California.

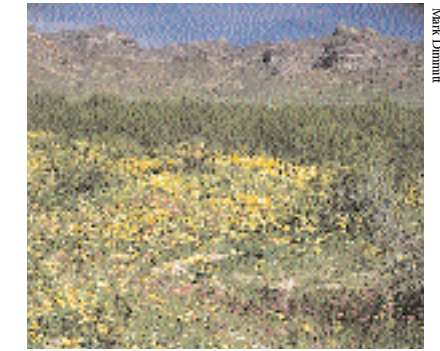
Whether we walk around in the heart of a desert city, or retreat to the most remote stretches of so-called wilderness in the U.S./Mexico borderlands, it is likely that at least one of 600 species of non-native plants and animals can be found within a few steps of where we stand. They are welcoming us to the Planet of the Weeds.

They are with us today, but are they here to stay, as David Quammen worries they will be? That depends, of course, on how honest we are in acknowledging the magnitude of this ecological dilemma and how diligent we are in our efforts to keep Sonoran Desert landscapes native.

Exotic Species: An Introduction Native Species: An Epitaph

Few people understand the severity of the current impact of exotics upon natives in the U.S./Mexico borderlands. The eco-tourist viewing desert wildlife refuges, national parks, biosphere reserves, and nature conservancy areas might well assume that large tracts of North America’s desert wilderness have remained intact, unaltered by humans. In reality these desert landscapes have been shaped by thousands of years of human influence. Indigenous cultures dispersed plants and animals into desert locales far beyond their natural ranges; agaves, beans, corn, gourds, chuckwallas, macaws, spiny-tailed iguanas, and turkeys are among the many organisms which prehistoric inhabitants of the desert moved and manipulated. Soon after the arrival of Europeans, human impact intensified. Seeds and stems recovered from the adobe walls of early missions prove that Jesuits and Franciscans brought more than bibles, grape vines and bread wheat with them from Europe; weed seeds were carried along in bags of crop seeds, and in the hooves of livestock.

Many environmental historians have thought that the aridity of deserts protects them, more than any other biome, from the effects of invasive species. Yet we find considerable evidence to the contrary: invasive species occur abundantly in Sonoran Desert habitats, even in areas remote from running rivers and flowing streams, or from metropolitan or irrigated agricultural areas. Researcher Ray Turner



Breathtaking Sonoran Desert wildflower displays can be threatened by invasive species.

notes that MacDougal Crater, near the western flanks of the Sierra Pinacate, now hosts Sahara mustard on the crater floor, despite the fact that grazing and other human-managed activities have been negligible there. Punta Cirio in the remote Sierra Bacha has also been invaded by this Mediterranean annual, even though it is miles away from agriculture. Tumamoc Hill in Tucson, the oldest scientific area free of domestic livestock anywhere in the deserts of the world, has added feral dogs, cats, and 52 exotic plants to its biota over the last century, but has lost at least 20 native species—18 plants and 2 mammals—over the same period, according to researchers Jan Bowers and Turner. Managers have estimated that as much as 60 percent of the vegetative cover of the Sonoita Creek-Patagonia reserve, the first Nature

Exotic species: An overview

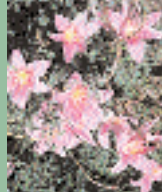
NATIVE SPECIES



desert mallow

One that evolved in a particular region or that evolved nearby and migrated to the region without help from humans.

NON-NATIVE SPECIES



rain lily

One that evolved in one region and was taken to another distant region by human activity where it would not naturally have migrated because of some barrier, such as an ocean. Also referred to as INTRODUCED SPECIES, EXOTIC SPECIES or ALIEN SPECIES.

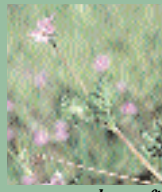
NATURALIZED SPECIES



African daisy

A non-native species that is reproducing in a new region without help (for example, irrigation) from man.

INVASIVE SPECIES



redstem filaree

An aggressive species that displaces other species; most commonly a naturalized species occupying a disturbed niche, although the most destructive invasives also displace natives in intact communities.

WEED



Sahara mustard

A native or non-native species that is unwanted and invasive in a landscape or agricultural setting.

Conservancy area in Arizona, is dominated by exotics, and that introduced fish pose a recurrent danger to its threatened native fish. Larry Stevens believes that invasives have played a major role in the continued loss of one native species per year from Grand Canyon National Park over the last two decades.

A high proportion of North America's micro-areal endemics, that is, unique plants and animals with restricted distributions, occur only in deserts. Invasive species endanger them. On the midriff islands of the Gulf of California, where endemism is highest in the region, Eric Mellink found that feral rats and cats have already threatened several small mammal and nesting bird species. The Baja California peninsula, also rich in endemics, is under conversion to buffelgrass pasture just as Sonora is, but on the peninsula this grass's escape into adjacent areas threatens many more natives with restricted ranges. Other areas rich in endemism—the oak woodlands of “sky islands,” the cienegas of the Desert Grasslands, and the oases of Sonoran Desertscrub—are also vulnerable to mass extinctions as a result of accidental introductions.

While competition with natives is usually given as the blanket reason for why exotic species are “bad,” their ecological impacts vary widely in effects and magnitudes. Some invasive species such as red brome, Lehmann's love grass and buf-

In a positive initiative known as “Pulling Together,” private and public U.S. organizations joined forces to map out and endorse a national strategy for dealing with invasive plants.

felgrass compete with natives for ground surface, soil moisture, and nutrients, but they also alter fire regimes and native plant regeneration patterns. Tamarisks not only compete for space and water in riparian habitats, they also disrupt stream flows, especially during flood stages.

Secondarily, these altered regimes may reduce resources for migratory pollinators and insectivorous waterfowl, thereby having a ripple effect throughout entire regional landscapes. In short, the ecological impacts of invasives are diverse, from cowbird predation on eggs to giardia infestations in vertebrate guts.

If most invasive species are so disruptive to the health and productivity of native biotic communities, what can be done about them? The answer is complex, and we need to consider both short-term and long-term causes of habitat change. Whatever actions we take should certainly link prevention, education, detection, control, restoration, and monitoring. The location of the Sonoran Desert within the

U.S./Mexico border region challenges us to detect species moving both ways across the international boundary. Although ubiquitous species such as tropical white flies and tumbleweeds cannot be stopped at the border, it may be possible to slow the intentional introduction of additional exotics by informing importers and border customs officials—as well as the public in general—of the high long-term costs of casually-introduced invaders.

The message needs to reach a wider audience. The Arizona-Sonora Desert Museum conference on the subject received front page coverage in Tucson newspapers, as well as a follow-up Sunday editorial entitled, “Beware These Invaders.” It appeared that science journalists in southern Arizona were astounded by how little they had known about the economic costs of bullfrogs, carp, tumbleweeds and tamarisks. The problem was called “a subtle, late-breaking and quietly astonishing crisis of ecological identity.” Many Arizonans learned for the first time that invasive plants and animals are among the top threats to endangered species and biodiversity globally, and by some accounts, the gravest threat to desert diversity.

In a positive initiative known as “Pulling Together,” private and public U.S. organizations joined forces to map out and endorse a national strategy for dealing with invasive plants. An Executive Order on Invasive Species

signed by President Clinton in early 1999 should help implement the strategy. Although Mexico does not yet have such a national agenda, it has an ambitious strategy for controlling exotics on the midriff islands of the Gulf of California that includes the use of witty and colorful comic books to alert fishermen to the perils of invasive animals. The real need is for agencies in both countries to be “pulling together” in the same direction, so that

one agricultural agency is not intentionally introducing cold-tolerant buffelgrass strains while another is attempting to eradicate it from a protected area just a few miles away.

We have many questions to answer if we are to deal effectively with the ecological invasions in the region as a whole:

- Do plants invade agricultural areas first, or roadsides?

- How do exotic aquatic animals disperse from waterhole to waterhole?
- Are ungrazed desert vegetation patches less prone to invasions than grazed areas?
- How do El Niño years fuel the spread of exotic animals and plants?
- Do the same control methods work in drought years as in wet years?

We face an even tougher question with many severe infestations: Do we need to use controls that carry additional risk, such as chemicals or the introduction of natural enemies of the invaders, which are themselves exotics?

Recently 33 field scientists ranked exotic grass plantings seventh and biological invasions tenth among the greatest stresses affecting the biodiversity of the Sonoran Desert region. If these two categories are combined, exotic plantings and related invasions rank among the five worst threats to our biodiversity. It is time to concede that we are beginning far too late to grapple with a problem of this magnitude, but that starting to deal with it earnestly today is better than never acting at all.



This article is adapted from a chapter by the same name in the future Arizona-Sonora Desert Museum publication, Invasive Exotic Species in the Sonoran Desert (working title), edited by Barbara Tellman.

Number of Exotic Species of Various Taxonomic Groups Established in the Sonoran Desert

Plants	232
Invertebrates	179
Fishes	57
Reptiles & Amphibians	13
Birds	7
Mammals	6

Controlling Invasive Exotics— The Right Tool for the Job

by Barbara Tellman
Water Resources Research Center
The University of Arizona



Volunteers removing tamarisk at The Nature Conservancy's Hassayampa River Preserve.

The first line of defense in controlling invasive exotics is to not let the invasion start. Don't let potential invasives in and if they do invade, eradicate them immediately. The U.S. Department of Agriculture spends millions of dollars each year to keep plants and insects from crossing the border; but even so, many new species are brought into the country each year accidentally or on purpose. Some of these thrive at the expense of natives, resulting in infestations such as the bullfrogs in many ponds and cienegas, and buffelgrass in Sonoran thornscrub. Are invasive exotics completely out of control? In some cases the answer is probably "yes," but we can still manage a good many of them, even if we can't eliminate them completely. There is, however, no one solution that will solve all the problems.

Basically, we have several choices:

- Remove them manually or by machine. These methods are usually very labor-intensive and sometimes result in even more plants if they resprout from the roots or grow from fragments.
- Remove them with chemicals. Use of chemicals can be risky unless they are first proven harmless to desirable species and without long-term effects.
- Use other species (natural enemies) to remove problem species—"biocontrol." Because the new species may themselves become problems, biocontrol is now strictly controlled in the United States.

The control agent must harm only the targeted species. Extensive trials are required. An advantage of biocontrol is that the change occurs gradually, allowing time for natives to replace the exotics.

- Interfere with their reproduction. These methods have reduced numbers of whiteflies after sterile males were released. They have also successfully yielded sterile young in exotic fish species.
- Change land management practices to encourage native plants at the expense of exotics. Many exotics only thrive in situations where human disturbance has created ideal conditions for them. When disturbance is reduced, natives may be able to compete successfully.

None of these methods carry 100 percent guarantees, nor are they totally risk-free. Often it takes a combination of methods to do the job, along with a lot of money and/or a lot of volunteer hours. Often repeat treatments are needed.

While there are some cases where control has been tried and has not succeeded, we do have some success stories in this region. The projects described in this issue by Sue Rutman and by Cecil Schwalbe and Phil Rosen are good examples of the challenges and initial signs of success.

Some other examples:

- At The Nature Conservancy's Hassayampa Preserve volunteers cut down tamarisk (saltcedar), then treat it

with chemicals to prevent regrowth. While there is still some tamarisk at the preserve, the targeted areas have been kept relatively free of it, allowing the native cottonwoods and willows to resprout in this relatively natural stream.

- In Sabino Canyon the Arizona Game and Fish Department and the U.S. Forest Service cooperated to eliminate exotic green sunfish from a three-mile section of the creek in order to improve conditions for native fish. They electroshocked the stream so that they could catch the native chubs and move them to a safe area, then dosed the creek with a fungus-derived substance that targets gill-breathing creatures. The sunfish are gone and other creatures such as frogs and turtles suffered no ill effects. A second treatment should ensure complete eradication.
- At The Nature Conservancy's Ramsey Canyon Preserve, an introduced landscape plant, *Vinca major*, dominated many areas along the creek. Volunteers (especially one dedicated local resident) systematically uprooted plants. Native plants have begun to recolonize many areas, but planting will be also be needed. Uprooting was not successful in rocky areas where the entire root systems couldn't be removed.
- Removal of livestock that grazed along a portion of the middle San Pedro River brought about a reduction in the number of saltcedar trees.

- On the other hand, The Nature Conservancy used controlled grazing to manage exotic Johnson grass at the Sonoita-Patagonia Preserve. They are replanting the area with native sacaton grass. Although they initially used fire to control the

Johnson grass, it thrived on fire, coming back better than ever.

Although there is hope of control for at least some infestations, the prospects for controlling others are limited, and the costs are generally high. Prevention is still the best approach.



Arizona Game & Fish Department

Salvinia molesta—A Growing Threat to Arizona's Waterways

by Barbara Tellman

An aquatic fern from South America has land managers in our region alarmed. Sold by nurseries for use in ponds, *Salvinia molesta* has now invaded the lower Colorado River. It grows rapidly even from tiny fragments of the plant, and under the right conditions it can double its mass in one to three weeks. It can survive in any waters that do not freeze over.

Salvinia forms floating mats up to two feet thick that block sunlight and oxygen, causing problems and even death for a variety of aquatic

life. Labeled the world's worst weed in the *Guinness Book of World Records*, *Salvinia* is a major problem in India, Sub-Saharan Africa, South-east Asia, and from the Southeast United States into Texas. The greatest immediate concern here is for the wildlife refuges vital to waterfowl along the lower Colorado River. Managers also fear that the weed will migrate to other rivers, lakes, stock ponds, irrigation systems, power plants, and canals. Recreational boats present the greatest potential for rapidly spreading *Salvinia* along the Colorado

River and to other waterways.

There is no easy way to remove it. Herbicides, biocontrol, manual removal, and drying up the water body are the main choices. Since the plant grows among other vegetation—cattails, willows, and saltcedar, for example—it is difficult to spray chemically or remove manually, and the proposed herbicides damage any vegetation they touch. Biocontrol with a weevil that only destroys *Salvinia* has been successful elsewhere, but there is concern about introducing another exotic species.

Water removal is an option for small ponds or canals, but not for the Colorado River. Besides, even after the plant has dried it can recover once water is again available. Most of these control tactics require permits; obtaining them can be a long and sometimes difficult process.

An interagency task force is considering options. Meanwhile avoid spreading it with your own watercraft, and if you sight the weed, please report the location to the U.S. Fish and Wildlife Service, (602) 640-2720.



Salvinia molesta (both photos)

Arizona Game & Fish Department

Bullfrogs—The Dinner Guests We're Sorry We Invited!

Cecil Schwalbe
U.S. Geological Survey, Biological Resources Division
and Phil Rosen
Department of Ecology and Evolutionary Biology
The University of Arizona



This bullfrog swallowed another of its kind. Bullfrog cannibalism in Arizona allows population densities up to 30 times those reported from the bullfrog's natural range in eastern United States.

Neek! Splash! A bullfrog hits the water. This sound, while a fond memory of our childhood hikes elsewhere, is now a clarion call to battle in a war that our native frogs, and even garter snakes, are losing to a host of introduced aquatic predators.

All six native species of true frogs in Arizona have suffered large losses since the early 1970s, with four in danger of disappearing from the state, and one already gone. The lowland leopard frog (*Rana yavapaiensis*), still common in central Arizona, has disappeared from southwestern Arizona, California, and New Mexico. The Mexican garter snake (*Thamnophis eques*), in dire straits in the U.S., and the declining narrow-headed garter snake (*Thamnophis rufipunctatus*) of central Arizona are both affected by introduced species.

Wetland loss was important in the decline of our native frogs, but the major current problem is non-native aquatic predators (fishes, crayfish, and the bullfrog *Rana catesbeiana*) from the eastern U.S. and Eurasia. Add newly discovered frog diseases to the mix, and the threats to native frogs throughout the American West are daunting.

We became acutely aware that there was a bullfrog problem while surveying the Mexican garter snake in 1985-86. At San Bernardino National Wildlife Refuge, east of Douglas, we found bullfrogs superabundant. The Mexican garter snakes consisted almost entirely of adults too big for bullfrogs to eat, yet most of the snakes had frog-chomped tails. Leopard frogs, common at

All six native species of true frogs in Arizona have suffered large losses since the early 1970s, with four in danger of disappearing from the state, and one already gone.

this refuge as recently as 1981, were reduced to a single site—too shallow for large bullfrogs—from which the leopard frogs disappeared during a drought in the late 1980s. Initial efforts to control bullfrogs allowed young garter snakes time to mature into adults, but these effects were not permanent.

The bullfrog's natural range stretched from Florida north to Canada, and west to New Mexico, but it is now established in every western state. Before 1900 the bullfrog was spread as a food and game animal. It thrives in deep, permanent, relatively still waters, most often found here in man-made ponds, lakes, or slow-flowing streams. The absence of its natural predators—especially snapping turtles and large water snakes—has helped it flourish. Arizona's garter snakes relish small bullfrogs, but large bullfrogs turn the table, eating juvenile garter snakes.

The bullfrog is the only frog or toad in Arizona that squawks when it leaps to safety—often setting off a mass bullfrog exodus—though all bullfrogs don't call

every time they flee. Leopard frogs don't squawk when fleeing; they also differ in having light-colored ridges running down each side of their backs and "leopard spots" surrounded by light halos. Bullfrogs are most commonly green, but colors vary widely, from olive to bronze to brown, sometimes with spots resembling camouflage clothing. Adult males sport bright yellow throats and conspicuous eardrums (much bigger than their eyes). Bullfrogs range from three-gram pipsqueaks to one-kilogram, eight-inch eating machines.

Our struggles to eliminate bullfrogs over the past decade and a half have taught us hard lessons. Bullfrogs seem impossible to remove from complex wetlands. Our hunting pressure produced wary frogs; we could not approach within 50 yards of some frogs before they left the water and sought refuge in pack rat nests. Merely launching a canoe spooked frogs out of a pond and into the adjacent marsh. Our intensive hunting and trapping efforts did reduce adult population numbers by 90 percent or more during the summer, but within a year, dispersal and rapid growth of young frogs almost restored adult population numbers.

Bullfrogs are extremely prolific, producing up to 20,000 eggs per clutch, five to ten times that of their native cousins in Arizona. Bullfrog tadpoles may also out-compete tadpoles of other true frogs. Additionally, unlike leopard frog tadpoles,

they are distasteful to fish, which gives bullfrogs a great advantage now that introduced predatory fishes are all over the Southwest.

Unlike fish, bullfrogs travel over land, a factor complicating their removal. On a night with summer rain, we commonly see small bullfrogs a quarter to a half mile from their ponds. At Buenos Aires National Wildlife Refuge this past summer, frogs traveled as far as two miles from the "home" pond, and we found evidence suggesting that dispersal four to five miles is likely.

Bullfrogs eat any prey they can get into their very large mouths, using their front feet to shove large items into their gullets. They most frequently eat invertebrates. Interesting stomach contents have included tarantulas, beetles, moths, centipedes, scorpions, dragon and damselflies, and toe biters (the three-inch long predacious true bugs that have been observed eating small frogs). One frog, apparently with a penchant for spicy food, had three tarantula hawks (large wasps that supposedly pack the most painful sting in the Southwest) in his stomach.

By weight, vertebrates play a major role in bullfrog diets. We found representatives of every non-marine vertebrate class in their stomachs. Some more spectacular items include a cotton rat, several other rodent species, bats, a nestling Red-winged Blackbird, Common Yellow-



Bullfrog Damage

Bullfrogs have almost eliminated the Mexican garter snake from the San Bernardino National Wildlife Refuge. The snakes remaining are almost all old, large females, with tails chewed by bullfrogs (inset).

throats (warblers), alligator and lesser earless lizards, Mexican and checkered garter snakes, western patchnose snakes, Sonoran mud turtles, leopard frogs, and threatened native fish. Even small bullfrogs can be fearsome predators on vertebrates. The smallest bullfrogs eat many small fish such as topminnows and chubs—probably because the small

fish frequent the same shallows—but the numbers of fish taken by bullfrogs still doesn't impact fish populations significantly. A 1.75-ounce bullfrog, at only half its weight at maturity, can easily eat newborn garter snakes or small lizards. The bullfrogs that had eaten bats were post-adolescents weighing about 3.5 ounces each. That supports observations

HOW DO WE GET RID OF THESE UNWANTED GUESTS?

In 1999 we started a leopard frog conservation project on Buenos Aires National Wildlife Refuge (BANWR) in the Altar Valley west of Tucson. We needed to rid the stock ponds of bullfrogs before attempting to reestablish native Chiricahua leopard frogs. Because BANWR is much drier than the San Bernardino refuge, we contend with much simpler aquatic systems there. However, eliminating bullfrogs even from individual stock ponds with no extensive springs or marshes still required a combination of techniques.

Fencing (to exclude or contain bullfrogs), drying of ponds, manual removal, and chlorination (to eliminate tadpoles or frogs hiding in the mud of drying ponds) seemed to be effective in eradicating frogs from five of six ponds on the refuge during this past summer. We will not know how effective those removals were until we re-survey the ponds next May and June. Attempting to remove bullfrogs anywhere is likely to take substantial efforts for some years, perhaps a decade or longer, and will require bullfrog-free buffers of at least several miles. The importance of livestock ponds as habitat for the threatened Chiricahua leopard frog warrants vigorous efforts to develop and maintain bullfrog-free stock ponds on both sanctuaries and working ranches.



A bullfrog enclosure fence around leopard frog ponds. Bullfrogs are so adept at climbing that enclosure fences must have eaves.



Cedric Schmalzer

Chiricahua leopard frogs were eliminated from the San Bernardino National Wildlife Refuge by bullfrogs and drought. They now are found on the refuge only inside bullfrog enclosures.

The absence of natural predators and the many abilities of bullfrogs have permitted them to dominate numerous perennial wetlands in the West.

by Arizona Game and Fish personnel and our field crew that bullfrogs seen jumping out of the water to catch bats on the wing were young adult frogs, not extremely large ones.

Surprisingly, bullfrogs' most common vertebrate prey is other bullfrogs. On several occasions, we found a bullfrog within a bullfrog within a bullfrog. At Arivaca Cienega we once witnessed a medium bullfrog swallow a smaller one, and then get swallowed by a larger bullfrog, all within a two-minute time span. We only half-jokingly refer to

bullfrogs as the "great white sharks of Arizona's waters."

The absence of natural predators and the many abilities of bullfrogs have permitted them to dominate numerous perennial wetlands in the West. Cannibalism enables bullfrogs to remain more abundant than their base of prey species would allow. Some of our study ponds had an adult bullfrog every two yards along the bank watching for movement of any potential food item. Adult population densities are abnormally high here—10 to 30 times those reported elsewhere. Leopard frogs, young garter snakes, or baby mud turtles have almost no chance of surviving in the waters of bullfrog-dominated ponds.

Clearly extraordinary measures are needed to eradicate bullfrogs from aquatic systems (see sidebar at left) and give native frogs, Mexican garter snakes, and other bullfrog prey items a fighting chance.



W. L. Minckley
Department of Biology
Arizona State University

When the Spanish arrived, the pristine Sonoran Desert region had little surface water and relatively few fishes, with at most only 36 species within Arizona's present borders. Far more water is impounded today in reservoirs and the number of species has soared! About 80 species, more than 50 from elsewhere, now swim in Arizona waters. Of the original 36, only 6 species persist throughout much of their natural ranges. One is extinct, 12 are endangered, 7 threatened, and 10 are of special concern. Although 8 of the threatened or endangered species survive in adjacent states, they have vanished from Arizona.

Early in this century large dams were constructed and canals built for water delivery, disrupting natural habitats. Carp, buffalofish, and catfish were stocked as foodfish before the 1920s. Human

The Conservation Dilemma of Non-native Versus Native Fishes

populations skyrocketed during and after World War II, increasing demands for sportfishing. By 1960, at least 20 exotic fishes were already established. In the 1950s and 1960s non-game species were removed so that gamefish could more readily colonize. Fish toxin was applied to hundreds of miles of western rivers before diverse trouts, basses, and catfishes were planted. A few exotic species arrived accidentally with gamefish shipments, while others, such as guppies, descended from discarded store-bought pets. Some species were planted to control noxious insects or plants; shad and minnows were stocked as food for gamefish or proliferated from discarded bait. Ever-larger predators—flathead catfish, northern pike, walleye, and striped bass—were imported and stocked. People moved some illegally to bring them closer to home. The introduced species spread through canals and desert streams stabilized by dams, artificial habitats which were to their liking, and many invaded natural streams from new centers of abundance, impacting native fish populations.

Why were exotics promoted and natives ignored or exterminated? First, government policy was to spread the "most desirable" fishes, mostly eastern species, throughout the nation. Second, most immigrants were from eastern United States and preferred the familiar species they knew from home over natives. Finally, management agencies

continued experimenting. If public interest waned or a stock declined, a "new" kind was planted; interest in novelties raised license sales.

Habitat destruction and alteration are often blamed for native fish disappearance. Clearly, as habitats dry, become polluted, or are otherwise made uninhabitable, fish die and species' ranges are reduced. Alterations such as temperature changes brought about by diversions and dams, and from watershed damage from grazing, logging, and road-building may also cause declines. Structures block migrations, a change to colder water stops reproduction by warm-water species, and streams are degraded by increased runoff and erosion from barren hillsides. Just as certain, however, is the fact that when exotics appear, as they invariably do in reservoirs or other stabilized habitats, native species decline, then vanish.

Among problems facing natives when exotics are present, predation seems most important. Carp, basses, sunfishes, catfishes, and other non-natives eat eggs and juveniles of suckers and chubs. Even though long-lived native fishes can persist for decades, too few young survive to reproduce, so populations disappear when old fish die. Alien mosquitofish eat baby topminnows and shred fins of adults, making them vulnerable to infections. Brown and brook trouts eat native trouts while also competing for space and food. Furthermore, rainbow trout, planted in



George Anandjko, Arizona Game & Fish Department

Some native fish recovery efforts appear to be working. For instance, reintroductions of Gila topminnows have almost doubled the number of sites where they live.



essentially all cooler waters, hybridize with native trouts to swamp them genetically. Moreover, non-native fishes carry alien parasites; an Asiatic tapeworm is presently spreading among natives, with unknown effects.

Since all native fishes tested so far do well in artificial waters without exotics, many indict non-native fish species as today's greatest deterrent to conserving our native species. Along with exotic fishes, other aliens including plants, crayfish, clams, snails, and bullfrogs, are proving just as dangerous.

Agencies charged with promoting non-native gamefish that impact natives, for which they also are responsible, have a hard time doing both jobs. The U.S. Fish & Wildlife Service (USFWS) administers the Endangered Species Act (ESA) for freshwater fishes. All federally funded programs fall under the ESA, so western states that depend heavily on USFWS hatcheries and funding are automatic partners, and managing fish resources is mostly their responsibility. State agencies sometimes resent federal control to a degree, and they may find little public support for non-game species. The USFWS has problems too. After all, it was instrumental in establishing non-native fisheries and helps maintain them. Now it must persuade development agencies, industry, sportfishing groups (the nation's most influential conservationists), and others to implement the ESA and

protect native fishes as well.

Despite all this, progress is being made. Recovery efforts are underway and some are working. Naturally spawned razorback sucker larvae were captured, grown in predator-free ponds, then repatriated when they were too large to be eaten. Soon, young adults were reproducing with old ones, so a life-history linkage was re-established. Reintroductions of topminnows have almost doubled the number of sites where they live. Other species too rare to manage in natural habitats are grown in hatcheries for reintroduction, or held there as stock for the future.

Here rises the dilemma. Non-natives impact natives in so many ways that only one solution seems to exist to ensure native species' survival — remove non-natives or provide habitats from which they are excluded. But exotics already are so wide ranging that total eradication is impossible, and furthermore, connections through canals, along with non-natives' invasiveness, make exclusion difficult at best. But isolation is possible. Exotics can be removed by the same chemical method used in the past to clear the way for gamefish. Stocks of imperiled natives, genetically pure trouts, for example, are then reintroduced. Now such efforts to renovate streams are being extended to benefit native warm-water species, most recently at Bylas Springs and in Sabino and West Turkey creeks, Arizona. Barriers

Non-natives impact natives in so many ways that only one solution seems to exist to ensure native species' survival — remove non-natives or provide habitats from which they are excluded.

such as artificial waterfalls are installed after renovation to stop invasion or reinvasion by non-natives. "No-fishing" rules and bans on transport of live fish or use of live baitfish are designed to stop reintroduction.

All these changes in regulations require cooperation among conservation authorities, land managers, and private landowners, and reflect a positive change in attitude toward native fishes. A number of places are set aside for native fish conservation; Aravaipa Canyon, San Bernardino-Leslie Creek National Wildlife Refuge, Canelo Cienega, and West Turkey Creek are some examples in Arizona. But even in such refuges, invasive exotic species remain major problems.

This is not to say that attitudes and practices have turned around entirely. Continued use of mosquitofish by public

health agencies to suppress insects is a case in point. Mosquitofish are advertised in the public media as available on request for pickup or delivery. Such stocking violates ESA rules against "take" if the known predator is planted with topminnow, perhaps even if the introduction results in later invasion of topminnow habitat. A conservation-minded citizen might easily contaminate a topminnow refuge by mistake. Who would then be responsible? Other problems exist, examples being a lack of agency emphasis on native fishes in the controversial San Pedro River and exclusion of the Colorado Delta in Mexico from imperiled-species plans.

The ESA has been manipulated, amended, and indicted, but it remains the most significant environmental law yet enacted. Funding to conserve native fishes is mostly from development agencies, industry, and conservation groups, sometimes under pressure to comply with the ESA, but often voluntarily. Many concerned people are confident that enough is known to perpetuate most

Sonoran Desert fishes, but support for new or revised conservation legislation is imperative if progress is to continue.

Finally, native fish survival depends on human wants, needs, and understanding. Explosive growth in human populations is placing ever-greater demands on the environment. And most human residents are new to the desert, with little understanding of resource limitations and certainly no idea that the familiar trouts, basses, catfishes, and other fishes they caught elsewhere as kids are not natural here.

Thus, education is sorely needed. Differences between natives and non-natives and contrasts between natural and artificial aquatic systems must be made clearer, and the roles and importance of native species better communicated. Life underwater is largely out of sight, thus out of mind. The growing public desire to perpetuate wildness and wilderness must be extended under water if native fishes are to remain part of our Sonoran Desert biotic heritage.



A green sunfish removed from Sabino Creek.



U.S. Bureau of Fisheries delivery car and fish-delivery truck. Arizona Game & Fish Department photo, ca. 1918.

Native fishes



THE SONORAN DESERT'S TEN LEAST WANTED



1 SAHARA MUSTARD

Brassica tournefortii

ORIGIN: Probably native to North Africa and central Asia

DESCRIPTION: Sahara mustard is a pernicious weed with no natural controls in North America. Known here for less than half a century, it now dominates thousands of square miles of sandy, low elevation desert, often to the nearly complete exclusion of native annuals. It is a major threat to our famous spring wildflower displays.

2 BUFFELGRASS

Pennisetum ciliare

ORIGIN: Native to eastern Africa's Great Rift Valley

DESCRIPTION: Buffelgrass was introduced by government and private agencies in Sonora and Arizona during the last four decades as a forage crop for lower elevation areas. It has become a scourge from Hermosillo, Sonora to central Arizona, reducing biodiversity by outcompeting native plants and by fueling fierce fires that cacti and other natives are not adapted to withstand.

3 JOHNSON GRASS

Sorghum halepense

ORIGIN: North Africa

DESCRIPTION: Johnson grass was brought to the U.S. during the late 1700s by a South Carolina family; it was introduced to Arizona as cattle fodder in the 1890s. It spreads quickly and is very difficult to eradicate, although many attempts have been made. It is common throughout southern Arizona at low- to mid-elevations. When under stress (frost or drought) the plant can become toxic to cattle and wildlife.

4 RED BROME

Bromus rubens

Origin: Mediterranean region

DESCRIPTION: This weedy annual was established in California by 1848; it is seasonally abundant and widespread in the Sonoran Desert region. Red brome's propensity to carry fires represents a real and growing danger to cacti and other native Sonoran Desert plants, which are not fire-adapted.

5 TAMARISK (also called saltcedar)

Tamarix ramosissima

ORIGIN: India

DESCRIPTION: This deep-rooted shrub or small tree consumes a great amount of water, thus leaving some areas high and dry. Its ability to out-compete willow, cottonwood, and other riparian plants has a dramatic effect on wildlife as well. During the winter, for instance, tamarisk stands have only 39 percent of the density of birds as other vegetative communities. Only a few native animal species use tamarisk.

6 FOUNTAIN GRASS

Pennisetum setaceum

ORIGIN: Africa

DESCRIPTION: This robust perennial clumping grass is a common landscape ornamental in southern Arizona, where it is slowly spreading into natural habitats, including the Tucson Mountains, especially washes. A few plants found in 1986 in Organ Pipe Cactus National Monument suggest that it may be spreading southward into Sonora, Mexico.

7 ARABIAN/MEDITERRANEAN GRASS

Schismus arabicus, S. barbatus

ORIGIN: Africa and Mediterranean region

DESCRIPTION: During years with wet winters, these closely-related winter annual grasses can be abundant across much of the northern part of the Sonoran Desert, forming extensive, dense carpets. The first stems and leaves often spread out close to the ground, effectively excluding or preventing other annuals from sprouting.

8 MALTA STARHISTLE

Centaurea melitensis

ORIGIN: Europe

DESCRIPTION: Malta starthistle perhaps was introduced to the Southwest as a contaminant in grain seed. In California it grows as a winter annual. Humans, animals, or wind can transport seeds. Dense infestations displace native plants and animals and degrade rangelands. The scale of infestation in Arizona may be relatively low at present, which enables an effective early response.

9 BULLFROG

Rana catesbeiana

ORIGIN: eastern United States

DESCRIPTION: This is the largest frog found in the United States. All bullfrogs west of the Rocky Mountains are the result of artificial introductions. Bullfrogs were introduced into Arizona as a food animal by the Game and Fish Department in 1926. These extremely prolific breeders are ravenous feeders, eating small rodents, lizards, snakes, turtles, fish, insects, and frogs, including other bullfrogs. They are quite detrimental to populations of native frogs, fishes, and aquatic snakes.

10 CRAYFISH

Procambarus clarki and Orconectes virilis

ORIGIN: Many species are native to the bayou country of the southern U.S.

DESCRIPTION: Crayfish have been introduced into freshwater systems around the United States. In the Santa Catalina Mountains near Tucson, they are common in most drainages with permanent water and can easily be observed in the biologically diverse Sabino Canyon. Sonoran Desert fishes evolved without such predators that also feed on plant material and compete for the substrates on which endangered or threatened species lay their eggs.



T. R. VanDewenter



Mark Danmitt



Steve Phillips



T. R. VanDewenter



Andy Asher



Steve Phillips



Cecil Schwalbe



Anahit Scoble



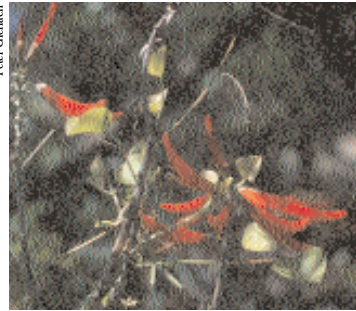
John M. Randall



David W. Lazzoni

Plant Stories of the Sonoran Desert

Peter Gierlach
Spadefoot Nursery
Host of "Growing Native" with Petey Mesquitey
on KXCI FM community radio



Coral bean

The desert that surrounds Tucson, Arizona, is beautiful. I wasn't aware of that when I first arrived in the fall of 1967. Born and raised in Kentucky and fresh out of three years in a boarding school, I wasn't quite prepared for the University of Arizona campus and its immense red brick buildings, student population almost equal to that of my hometown, and flood-irrigated landscape with plants that I'd only seen in books. I probably should have read the catalog a little more closely, because I wasn't ready for the mandatory ROTC either.

If you were to ask me what Tucson was like, all I could tell you about was the area around campus. Not until I started leaving the campus and Tucson itself did I see what the desert was about—an incredibly diverse landscape full of plants and animals that were so different from anything I had experienced. And, oh my gosh, if you climbed a small hill you could see for miles through a forest of ironwood trees and palo verdes and saguaros! It was so much better than the desert of the Western movies and books of my youth, because I was in it and it was real! Tucson itself was a landscape full of exotic species—palms, African sumacs, pepper trees, Italian cypress, and Aleppo pines—with just a smattering of plants native to the desert that surrounded it. It was as if people needed to surround themselves with plants that were a lush reminder of where they had come from. But for me, the Sonoran Desert was beau-

tiful—so different from where I grew up, but so beautiful.

Now, so many years later, I suppose it makes sense that for a living I grow plants native to the Southwest. (The "for a living" part is debatable, but I do grow native plants.) And the more I grow them, the more I come to love the unusual region we live in—an arid land where mountain ranges rise up to create "sky islands." It is a land of little rain, yet with a diverse mix of plants and animals living together in incredible relationships. It's a land of wonderful ecology, a land of wonderful stories, a hot land with cool plants. I want to tell you about just a few of these plants that grow in the desert. They may not be the usual plants you think of when you think of the desert, but they are plants with stories that grow in the glorious arid land that surrounds you and me.

Chuparosa, or *Justicia californica*, grows in the low desert. Its gray-green twigs are bare during dry times, but with a little rain those twigs fill with leaves and red tubular flowers—lots of red flowers. On warm, rocky slopes or along arroyos you'll see their incredible splashes of red. And yes, *chuparosa* does attract hummingbirds. In fact, in Spanish "chuparosa" means hummingbird and those red tubular blossoms full of nectar keep hummingbirds very busy and nourished.

Years ago I was hiking in the Coyote Mountains west of Tucson. It was late February and we'd had good winter rains. The slopes were covered in blooming

Years ago I was hiking in the Coyote Mountains west of Tucson. It was late February and we'd had good winter rains. The slopes were covered in blooming chuparosa and the ocotillo had leafed out to green canes topped with red flowers. I had never seen so many hummingbirds. I wore a red cap that day and as I sat on a warm boulder, I became a part of that landscape as hummingbirds flew from plant to my cap to plant.

chuparosa and the ocotillo had leafed out to green canes topped with red flowers. I had never seen so many hummingbirds. I wore a red cap that day and as I sat on a warm boulder, I became a part of that landscape as hummingbirds flew from plant to my cap to plant.

When I'm learning about a new plant, I like to look in books to see if it

has any medicinal uses or if indigenous people used it and if they passed those uses along. These things make plants even more interesting and give them stories.

Pipe vine, or *Aristolochia watsonii*, has stories. The genus is derived from the Greek words meaning "best for birth," and another common name for it is birthwort. Modern herbalists still declare its many uses. But what I like best is that without pipe vines there would be no pipe vine swallowtails. The incredibly ill-smelling foliage of the pipe vine is the larval food of the pipe vine swallowtail butterfly. Many times when I see the plant, it is covered in caterpillars.

Caterpillars remind me of another ill-smelling desert plant called *Passiflora foetida*. "This native passionflower vine will bring gulf fritillary butterflies to your yard. It's their larval food," I said to a nursery customer. Later that fall I asked her if she had seen the butterflies and she said no, she hadn't, but she had spent the summer picking caterpillars off the vine.

Among the warm boulders just above the desert floor you'll find *Erythrina flabelliformis*, or coral bean to those afraid of that botanical name. Actually, you may not see coral bean but instead find its bright red, hard beans on the ground. Look around you and you may see some naked, brittle branches pushing out of the cracks in a boulder, maybe a dried pod hanging on them. That's coral bean. Isn't it glorious?! If you come to the same spot in the late spring

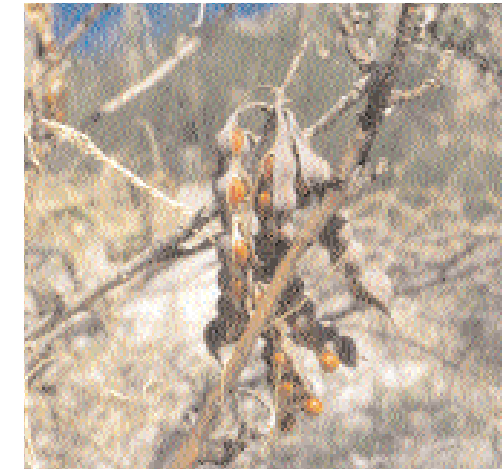
or early summer, the tops of those naked branches will have flame-red flowers and the fan-shaped (hey, that's what *flabelliformis* means) leaves will cover those branches and long green pods will dangle where once there were flowers. In the fall, the leaves of coral bean turn a beautiful yellow and drop, leaving long pods. The pods dry and open, revealing a row of bright red beans—coral beans. The beans are said to be poisonous, but they are so hard I can't imagine anyone getting poisoned without breaking some teeth.

Once a fellow who had grown up in Tucson came into my nursery, and he recognized that I was growing coral beans. "Oh, that's burning bean plant," he said to me. "What?" I said. "When I was a little boy we'd take those hard beans and rub them on a rock 'til they were real hot and then touch each other with them—burning beans!" It's glorious.

For many years I lived northwest of Tucson in what is called the Ironwood Forest. It is a desert full of ironwood trees, palo verdes, mesquites, acacias, saguaros, barrel cactus, cholla, prickly pear—oh, just too many plants to list—but that area was my education. My love of the desert grew there, and I came to feel a sense of place in that desert. There was a cactus there called "queen of the night" (*Peniocereus greggii*) or the beautiful Spanish name, *la reina de la noche*. It is almost always found under a tree because the seed from the fruit is spread by birds. Dead-looking ribbed branches attached to



a large tuberous root stick out of the ground. They are hard to find except on one night in June or early July when they bloom. Immense, funnel-shaped white blossoms, six inches tall and four inches across, suddenly appear on the dead-looking branches. An incredible fragrance permeates the air and attracts the sphinx moths. My wife and I would take our daughters into the desert to see *la reina de la noche*. We'd call friends and they would come to see, because it is only one night. We told stories, and those nights became stories, stories about plants and animals, not just old stories, but new stories. Our stories remind us over and over about the beauty of the Sonoran Desert.



Coral bean

Battling Buffelgrass: You Can't Win If You Don't Play

Sue Rutman
Organ Pipe Cactus National Monument



Side-blotched lizard three inches long challenged my walk in the desert. His blue shoulder markings flashed as he did his push-ups to impress me with his vigor and to defend his territory. I posed no threat to him, but a more serious and silent intruder was on its way. Buffelgrass was invading Organ Pipe Cactus National Monument.

Buffelgrass was brought to Tucson from Africa, the Middle East, and India in 1939. Scientists with the U.S. Department of Agriculture, Plant Materials Center in Tucson experimented with buffelgrass for decades. They hoped this rapidly growing, drought-tolerant grass would provide abundant livestock forage and stop soil erosion. Buffelgrass inevitably escaped from the experimental plots and began spreading exponentially. Only 45 years or so after its arrival in Tucson, buffelgrass was found more than 100 miles away at Organ Pipe Cactus National Monument. In the mid-1980s, Dr. Richard Felger described the species as being “uncommon, perhaps rare” but increasing at Organ Pipe. Over the next 10 years, buffelgrass populations rapidly expanded and the species became established on more than 20 square miles of wilderness.

Volunteer Tom Wilder holding a large buffelgrass plant that is several years old. Plants this size can produce thousands of seeds per year.

Buffelgrass aggressively colonizes and rapidly alters Sonoran Desert communities. Mature plants can be as tall as three feet, larger than most native grasses. Buffelgrass competes with native plant species for water, nutrients, and space. Seedlings of many native plants can not survive under the thick layer of buffelgrass. Neither can many lizards, which depend on sunny areas when they need to raise their body temperatures. Rodent populations shift from species that prefer open desert habitats to species more typical of grasslands. Gambel's quail and other ground-feeding birds have difficulty moving through the dense grass and lose their access to a nutritious mix of seeds, greens, and the invertebrates important to hatching diets. It's no surprise that nectar-feeding birds and insects also lose their food sources when wind-pollinated grasses take over. Monotonous grass fields replace winter and summer wildflower shows.

Of all the effects African grasses have had on the Sonoran Desert, fire is the most serious. Fire did not naturally occur in the desert because plants are too far apart for fire to spread. Grasses and other non-native plants provide the fuel that connects the sparse native plants. Since the arrival of non-native grasses, fires in the desert have increased in frequency and magnitude. Most native desert plants die when burned and do not re-establish quickly in burned areas. Burned buffelgrass can push up new stalks within days after a fire and new seedlings sprout

The arrival of buffelgrass on Organ Pipe evoked visions of a dismal future. If uncontested, the ecological effects of this species would be severe, widespread, and perhaps permanent.

readily on the barren ground. Burned areas become fields of buffelgrass that are difficult to eradicate.

The arrival of buffelgrass on Organ Pipe evoked visions of a dismal future. If uncontested, the ecological effects of this species would be severe, widespread, and perhaps permanent. The National Park Service would fail at its most fundamental mission: to preserve and protect the area for future generations. Would we soon be presiding over an African savanna? The risk of doing nothing was too great, but how were we to respond?

Experts were doubtful or pessimistic about controlling buffelgrass. No one had tried eradicating the species on a large scale. Academic ecologists advised against mechanical control (digging up plants) because the disturbance of digging would likely favor the species, not eradicate it. But herbicides didn't kill the plants and

neither did burning. Given no other options, we started experimenting with mechanical control.

We started work on a conveniently located test area in November 1994. Sixteen employees and volunteers removed buffelgrass from along Arizona State Route 85 near the visitor center at Organ Pipe. In two hours we removed more than 50 large trash bags of buffelgrass from about 0.1 mile of roadside. The bags were taken to the municipal dump and were buried.

The results gave us reason to be optimistic. One year after the test project, we spent one day removing seedlings. Two years after the test project and thereafter, we removed one to three seedlings per year.

Buoyed by the success of the test project, we moved on to a large infestation covering several square miles west of Quitobaquito Springs along the U.S./Mexico International Boundary. During the spring of 1996, a group of students from Earlham College, Illinois, spent two days in the area and removed several tons of buffelgrass. We were surprised to see very little reestablishment, even now after several years.

These small and encouraging efforts implied that mechanical removal could be successful if eradication sites were visited for at least two years. During the second year, seedlings could be removed before they produced seeds. With no input of seeds the buffelgrass population

could not reestablish or expand. With continual, but low-effort maintenance, buffelgrass control seemed possible and effective.

The buffelgrass control program at Organ Pipe shifted into high gear during the winter of 1997-1998. That winter, two volunteers and employees spent a total of 890 hours removing buffelgrass. By the spring of 1998, nearly the entire Monument, with the exception of the extreme southwestern corner, had been cleared of buffelgrass. During the winter of 1998-1999 volunteers and employees spent about 1,000 hours removing buffelgrass from the southwest corner and Dos



Because of frequent and severe buffelgrass fires (left), many wooden fence posts in Sonora have been replaced by concrete ones (right).



In this monotonous buffelgrass field in Sonora, Mexico, the needs of one species—cattle—has left few resources for native plants and animals.



Constant vigilance will be necessary to protect and preserve this beautiful desert landscape from buffelgrass and other invasive species.

Steve Phillips

It is unlikely that Organ Pipe will ever be able to totally escape this potentially devastating species. But if we remain vigilant against new occurrences and root them out when we find them, our goal of minimizing buffelgrass infestations seems attainable—at least for now.

Lomitas area (the southeast boundary), and surveying areas in the west-central and northwestern part of the Monument. Small (room-sized) outlying populations were found and eradicated. By the spring of 1999, we estimated that 100 tons

of buffelgrass had been removed from Organ Pipe.

The buffelgrass control program on Organ Pipe Cactus National Monument has been a success so far. Time and monitoring will determine how long the success story will last. Of particular interest will be the response of buffelgrass to the above-average rainfall of the summer of 1999.

Given the vast populations of buffelgrass in neighboring Sonora, Mexico, their seeds will surely hitch rides into the Monument with truck tires and dust devils. It is unlikely that Organ Pipe will ever be able to totally escape this potentially devastating species. But if we remain vigilant against new occurrences and root them out when we find them, our goal of minimizing buffelgrass infestations seems attainable—at least for now. We owe as much to that side-blotched lizard!



Buffelgrass

Red Brome and Wildfires

Jerry Asher
USDI Bureau of Land Management
Oregon State Office



Red brome

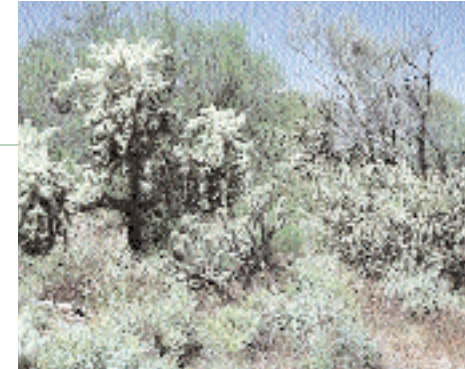
Unprecedented and unnatural wildfires are destroying native plant communities of the Sonoran Desert. Within the last seven years destructive wildfires have consumed large tracts of some of the most scenic and species-rich parts of the desert.

Red brome, an annual grass native to the Mediterranean region, arrived in southern Arizona around 1900. It grows in dense stands of closely spaced, erect stems, providing abundant fuel between the widely-spaced native plants. Red brome grows back more vigorously after fire, and with more red brome, there's more fire—an accelerating self-perpetuating fire cycle.

Even though some native plants resprout, populations of most perennial plants are catastrophically reduced or eliminated, especially after repeated fires. Many mature saguaros and most young saguaros are often killed with a single fire. Smaller cacti such as pincushions, hedgehogs, prickly pear, and all species of cholla are usually killed, as well as palo verde trees. While the damage from red brome (and to a lesser degree other non-native grasses) is already extensive and landscapes permanently altered, we have only begun to see the scope of the degradation that is set to occur on a grand scale.



The top photograph was taken 22 miles north of Oracle, Arizona, prior to a May 1995 fire involving red brome. The middle photo shows the aftermath of the fire and its devastating effects on native vegetation. The bottom photo was taken less than one year after the fire. Note the increased abundance of red brome.



T. R. Vandewater (all)



Pulling Together: The Desert Museum Battles a Biological Wildfire

Patty West
former Research Coordinator
Arizona-Sonora Desert Museum

Barb Skye
Curator of Botany
Arizona-Sonora Desert Museum



Antoinette Segede

If you think that controlling weeds in your yard or garden is a challenge, consider the immensity of controlling the over 220 non-native plants in the Sonoran Desert region. These plants have hitched rides here by nestling in socks, sticking to dogs, hiding between the treads of tires, or traveling in human hands. If you add to this number over 40 fishes, 7 mammals, 7 birds, 130 invertebrates, and 13 reptiles and amphibians that have all hopped, swum, flown, crawled, or been transported to the Sonoran Desert region you have a number of exotic species estimated to be about 400. This overwhelming menagerie of creatures that have invaded an area more than ten times the size of Connecticut can only be addressed by cooperation between the agencies and countries that span this region. The Arizona-Sonora Desert Museum is one of the many private organizations and public agencies that are working together to identify which plants and animals may cause ecological and economic problems. Collectively, we hope to implement the most effective, most efficient and least disruptive ways to deal with these species.

The Arizona-Sonora Desert Museum has facilitated the cooperation needed to address these biological invasions. In May of 1998 the symposium "Invasive Species in Sonoran Desert Ecosystems" brought together researchers, government officials, and concerned citizens to address the problems of non-

native biological invasions in the Sonoran Desert region. Further cooperative efforts are an ongoing result of the symposium. Since that seminal gathering of interested people our staff has initiated and participated in related projects on the museum grounds and in the greater Sonoran Desert region. The projects mentioned below reflect a multi-pronged approach, including prevention, education, research, monitoring, control, and eradication of non-native species.

On the grounds

On Museum grounds we continually remove invasive non-native plants, primarily pulling them by hand or using other mechanical means. We feature native plants on the grounds in an effort to promote their use in home landscapes. We are also monitoring spiny-tailed iguanas that were introduced to the Museum grounds 20 years ago to evaluate their potential invasiveness.

In January, 2000, the Desert Museum created a special task force which became the Tucson Mountain Weedwackers (TMWW.) This group is dedicated to the eradication of invasive non-native plants in the Tucson Mountains. This collaborative organization includes the Arizona-Sonora Desert Museum, Pima County's Tucson Mountain Park, Saguaro National Park, The Sonoran Arthropod Studies Institute, and hundreds of community volunteers. The TMWW group educates

the general public about the preservation of biological diversity through invasive species control with hands-on training and outreach classes. In less than two years, over 500 Weedwacker volunteers have removed fountain grass and buffelgrass from more than 5,000 acres of Tucson Mountain parklands.

We generated comprehensive, definitive lists of non-native plants and animals in the Sonoran Desert including the floras of the Tucson Mountains and Ragged Top. Currently, ASDM scientists, in cooperation with BLM, are compiling a biological inventory at the Ironwood National Monument. The Desert Museum plans to create other educational materials on invasives, among them a guide to threatening non-natives on islands in the Gulf of California. We contributed to a management plan for these islands that emphasizes non-native species control.

We initiated a program in which members of the Seri Indian community are trained in methods to control non-native weeds and rats, integrating modern biological techniques and ideas with

traditional knowledge. The trainees are uniquely qualified to fill research and conservation posts on the islands and coast of the Gulf of California, a benefit to their economy as well as to their environment. When possible, we will participate in other international efforts to coordinate invasive species control efforts.

The Museum will continue to make information on invasive plants and other species more accessible to the public through educational programs, publications, and expansion of our website (www.desertmuseum.org.)

With other agencies

The Desert Museum is committed to cooperating with other agencies and organizations, and with people in desert communities, in their efforts to keep the unique habitats of the Sonoran Desert from being further invaded by non-native plants and animals. We hope that by working together, we can succeed in bringing this biological "wildfire" under control.



Karen Krebs

Para-ecologist courses are training Seri Indians in methods for controlling non-native plants and animals.



Jeanne Broome

Jeanne Broome

ASDM efforts

Invasive Plant Management in the Sonoran Desert: An Update

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Since the initial publication of the “Bioinvaders” issue of *sonorensis* in the winter of 1999, much has happened in the arena of invasive species management. During the past few years, a critical increase in awareness has occurred regarding the seriousness of the problem at the national, state, and local levels. In this article we provide an overview of the most important recent advances in the management of invasive plants, with a focus on activities within the Sonoran Desert Ecoregion.

A national call to action

In February 1999 President Clinton issued an Executive Order on invasive species. This action continues to bring national attention to the threat invasive

species pose to our nation’s economy and natural heritage. The order established the National Invasive Species Council, whose tasks are to provide national leadership on invasive species and to ensure that federal agency activities concerning such species are coordinated, complementary, cost-efficient, and effective. The council includes several federal departments and agencies and is co-chaired by the Secretaries of the Interior, Agriculture, and Commerce. The order required the preparation of the National Invasive Species Management Plan, whose first edition was completed in January 2001. The plan provides a blueprint for federal action in coordination with other governmental entities and stakeholders to prevent the introduction of invasive species, provide for their control, and minimize their impacts. The order also established a stakeholder Invasive Species Advisory Committee to assist in the implementation of the national management plan. The Nature Conservancy is one such stakeholder organization that is a member of the advisory committee.

Parallel to the above efforts, other important initiatives are underway at the national level that relate to the management of invasive plants. Consistency in the collection of data that documents the occurrence of invasive plants is crucial for accurately tracking their spread and assessing their impacts. Recently, the North American Weed Management Association, a membership-based national

organization, worked with federal agency technical staff to develop standards for mapping the occurrence of invasive plants. These standards already have been adopted by a number of federal land management agencies, as well as by other organizations in the United States and Canada. The association currently is developing standards for weed-free hay, of particular importance to western states, and for monitoring the use of biocontrol agents. A primary need is adequate funding for on-the-ground control activities by locally organized groups. Congress has taken up legislation that would provide federal matching dollars through the states to support such activities. Although a bill has yet to pass, the increased awareness within Congress that adequate funding is needed is a positive step forward.

Arizona responds

Until the late 1990s the focus of invasive plant management activities in Arizona had been on federal- and state-regulated noxious weeds—generally species that have an impact on agriculture—and mostly concentrated within the northern part of the state. Several recent events not only have highlighted concerns about invasive plants within the semi-desert grassland and desert areas of the southern part of the state, but also have turned attention to their impact on Arizona’s wildlands. Symposiums and workshops hosted by organizations such as the Arizona-Sonora Desert Museum

Partnerships that cross boundaries—not only of ownership, but also of values, interests, and capabilities—will be a prerequisite for success.

(1998), Organ Pipe Cactus National Monument (1999), and others; ecological analyses, resource guides, and public outreach materials; and the efforts of numerous dedicated individuals all have contributed to a new focus and sense of urgency.

The threat posed by invasive plants to Sonoran Desert biodiversity needs a comprehensive response. In the remainder of this article, we discuss the nature of the Arizona response, primarily in regard to the Sonoran Desert. Response strategies largely fall into the following categories: partnerships, public policy, technological tools, and education and outreach.

Partnerships: crossing boundaries

Invasive plants do not respect boundaries; they move with equal disregard across international, state, and landownership lines. They impact private and public lands, rural and urban areas, ranches, farms, and wildlands alike. To prevent their movements and control their impacts, we must respond in kind. Partnerships that cross boundaries—not

only of ownership, but also of values, interests, and capabilities—will be a prerequisite for success. My neighbor’s problem is my problem; together we can solve it. In addition to landowners and managers, we also must include land users, whose actions may spread reproductive parts of plants or otherwise create conditions favorable to colonization by invasive plants. Partnerships play a key role in leveraging and effectively using the scarce resources—funds, tools, personnel, and knowledge—that are available to manage invasive plants.

In contrast to many of its sister states in the West, Arizona currently lacks a state-imposed organizational and funding infrastructure that dictates how at least noxious weeds are managed. In the last few years, however, more than ten volunteer and local organizations have been created within Arizona that cooperatively manage invasive species. Known generally as Cooperative Weed Management Areas (CWMA), these grass-roots organizations include any combination of representation from: county, state, and federal government; private landowners; academic and other technical assistance institutions; non-governmental organizations; tribes; and natural resource conservation and irrigation districts. They are organized either on a geographic basis, with cooperators generally sharing a common suite of invasive plants, or in some cases are designed to address a particular problematic species no matter where it occurs. Still other groups,

such as Tucson Mountain Weedwackers, are informally organized and may focus on a limited geographic area or set of partners. As volunteer organizations, CWMA’s in Arizona face the common challenges of securing enough people and funding to accomplish their work.

To complement on-the-ground actions of CWMA’s and to provide them assistance toward achieving their goals, other types of coordinating bodies have been established or are contemplated. These groups, such as the Southwest Vegetation Management Association and Pima Invasive Species Council, which address invasive plant issues in Arizona and Pima County, respectively, can act as advocacy bodies for public policy reform and research needs, sources of technical and educational information, and clearinghouses for identifying grant opportunities.

Public policy reform

Without effective public policy, management strategies for invasive species are difficult to implement and sustain. One of the purposes of this issue of *sonorensis* is to increase the awareness of policy makers. Because the Sonoran Desert extends into portions of Baja California and Sonora, Mexico, policy reform and coordination must encompass international as well as state and national issues. Recently, a number of individuals and organizations within the Sonoran Desert Ecoregion petitioned the Arizona Department of Agriculture to add four



Kasey Anderson

Bob Perrill

Exotic Grasses & Native Wildlife

wildland invasive species to the list of state-regulated species. Management of one of these species, buffelgrass (*Pennisetum ciliare*), also has been proposed as a case study that could serve to improve coordination of federal policy on invasive species. On the horizon is the development of an Arizona invasive species management strategy that could provide the impetus and blueprint for the state's plan of action to support and fund invasive species management across the state.

Using technology

The effectiveness of CWMA can be improved through the strategic development and consistent application of technical support tools. Such tools should not only lead to better coordination among CWMA participants, but also link CWMA data collection and analysis results with regional and national efforts. The Southwest Exotic Plant Mapping Program (SWEMP), managed by the U.S. Geological Survey's Colorado Plateau Field Station in Flagstaff, is an example of a collaborative effort to develop regional information on the distribution and abundance of invasive plants. By applying common core standards of data collection and using compatible database software, CWMA participants can facilitate information exchange and better plan response strategies with their cooperators. In addition, they

can make their data useful at larger geographic scales of analysis. Regional and national analyses of species occurrence data may permit forecasting the potential spread of invasive species and lead to more effective preventive measures. Other critical technical needs include: species-specific research on basic biology, impacts to biodiversity, and control methods; tools for priority-setting; and simulation models that can better predict potential spread and impacts of invasive species.

Getting the message out

Although progress has been made toward management of invasive plants in the Sonoran Desert specifically and Arizona in general, much work remains, and a continued commitment to action is needed. Education and outreach—vital tools for raising awareness among policy makers and the public in general—will take on greater importance in the years ahead. The messages that convey the impacts of invasive plants are there for those who are willing to read them: impoverished grazing lands, degraded wildlife habitat, potential for fire within ecosystems that did not evolve with fire, reduced crop yields, devalued real estate, and loss of biodiversity. These messages need to reach all who can make a difference, and we all need to be messengers.



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Plains lovegrass

Exotic lovegrasses, purposely introduced in the 1940s, have spread through southeastern Arizona, crowding out native plants in some of the state's most productive grasslands. Casual observations made us suspect that the diversity of living things might be reduced in the areas dominated by these exotics.

At the end of the nineteenth century overgrazing by domestic livestock coupled with a prolonged drought denuded large areas and greatly reduced plant cover in others. In an effort to restore the range for cattle, the Soil Conservation Service planted two species of African grasses—Lehmann's lovegrass, *E. lehmanniana*, and Boer lovegrass, *E. curvula*. The grasslands were formerly a mixture of native grasses, including plains lovegrass (*E. intermedia*), and other plants. Now African lovegrasses almost totally dominate parts of some mesas.

A cotton rat is the only common rodent in exotic grasslands at the Research Ranch.



In the mid-1980s we compared plants, birds, small mammals, and grasshoppers living in stands of native grasses with those in adjacent areas covered with exotic grasses. Our studies took place at the 8000-acre Appleton-Whittell Research Ranch Sanctuary of the National Audubon Society in the foothills of the Huachuca Mountains.

Plants were much less diverse in the exotic grass stands. Not only were the native grasses rare in the exotic stands, but native wildflowers and shrubs were missing or scarce as well. Only mesquite trees did equally well in both. Since exotic lovegrasses form very dense patches, it is not surprising that most native plants were unable to grow among them.

With one exception, the summer resident birds preferred native grassland. (If you want to see such species as Eastern Meadowlarks and Cassin's Sparrows in the summer, visit native, not exotic, grasslands.) The exception is Botteri's Sparrow, which appears to prefer the exotic Boer lovegrass stands instead of areas covered with native grasses. These sparrows also favor bottomlands covered with sacaton grass (*Sporobolus wrightii*), a native flood-

plain species that also occurs in dense, tall, somewhat uniform stands. Birds present in the winter have the same preferences as the summer residents.

We found a similar pattern in the rodents. Most rodents, including the insectivorous pygmy mouse (*Baiomys taylori*), preferred native grassland. The only rodent that favored exotic stands was the native Arizona cotton rat (*Sigmodon arizonae*). Like the Botteri's Sparrow, this animal is also common in sacaton bottomlands. Twice as many kinds of grasshoppers, important in the food chain of our grasslands, were common in native than were common in exotic stands. Ironically cattle, too, prefer the native grasses, turning to the African grasses only when nothing else is available.

Areas with diverse native species are more interesting and aesthetically pleasing than are uniform stands of African grasses. But more importantly, diverse native communities are a natural gene bank—one that has passed through an evolutionary sieve that allows them to survive under our extreme conditions. The lesson is clear: Learn from the past. Foster diversity in both plants and animals by planting natives.



The Botteri's sparrow (foreground) is one of the few animals more common in exotic grasslands, whereas the closely-related Cassin's sparrow (background) is one of a variety of birds that are much more common in native grasslands.



Stands of Boer lovegrass, such as this one at the Research Ranch, support a much reduced variety of native plants and animals, compared to native grasslands.



Al Morgan

What Can You Do?

At Home

- Begin with your own yard. Landscape with native species or non-invasive plants appropriate for your area, and keep your property free of invasive weeds.
- When you plant exotics in your yard watch carefully for signs of aggressive spread; take appropriate action if it is observed.
- Neuter your pet cats and dogs or keep them confined. Don't release pets into the desert, or aquarium plants and fish into desert waterways.
- Avoid disturbing natural areas—disturbed ground favors invasive exotics.
- Be careful not to send or receive potentially harmful plants or animals through the mail. Know what you're sending and receiving!

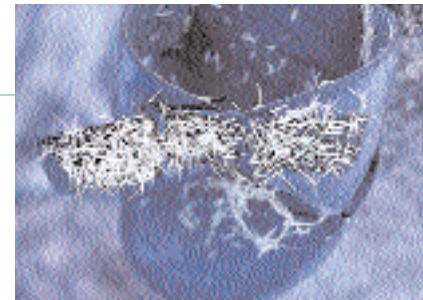


Rosa Lefkowitz

Native plants are beautiful! They can bring year round color and texture into your yard and your community (left and above). Desert hikers and campers should be careful to clean their gear and clothing before returning home (top right).

In the Community

- Adopt a local roadside, trail, park area, or riparian area. Develop a program for detecting, reporting, and possibly controlling weed infestations. Work with community leaders or land managers in developing such a program.
- Document the location of noxious weeds in your community through the use of maps, photos, and survey forms. Share the information with community planners and land managers.
- Native plants are beautiful! Prove it to your community by starting a native plants demonstration garden.
- Go public. Conduct a public awareness campaign to educate local citizens about steps they can take to stem the spread of exotic plants and animals.
- Work with county extension agents and local land management agencies to put up informational signs where weed infestations occur.
- Tell your friends and relatives about this problem.



T. R. VanDewender

When You Travel

- Clean all camping gear, clothing, and shoes before leaving an area to avoid inadvertently taking seeds along to the next campsite, county, or state.
- Don't camp in or hike through weed infested areas. Stay on designated trails.
- Refrain from picking wildflowers or digging up plants.
- Don't bring plants, fruits, soil, or animals into the country from abroad illegally or without having them inspected by quarantine officials; fill out agricultural declaration forms completely and honestly.
- Completely wash down boats and boating equipment and blow out personal watercraft intakes before transporting them from one water body to another. Don't dump bait in the water!



2021 N. Kinney Road • Tucson, AZ 85743-8918
520.883.1380 • www.desertmuseum.org

The Arizona-Sonora Desert Museum is a private nonprofit educational institution whose mission is to inspire people to live in harmony with the natural world by fostering love, appreciation and understanding of the Sonoran Desert. Founded in 1952, it is recognized worldwide as a leader in natural history interpretation and exhibitory. Through its combination of zoological, botanical, geological and natural history presentations, ASDM stresses the vital interrelationships of the land, water, plants, wildlife and people of the Sonoran Desert region.



7650 E. Broadway Blvd., 203 • Tucson, AZ 85710
520.290.0828 • www.sonoran.org

The Sonoran Institute, founded in 1990, is a nonprofit organization that works with communities to conserve and restore important natural landscapes in western North America, including the wildlife and cultural values of these lands. The Sonoran Institute's community stewardship work creates lasting benefits, including healthy landscapes and vibrant, livable communities that embrace conservation as an integral element of their economies and quality of life.

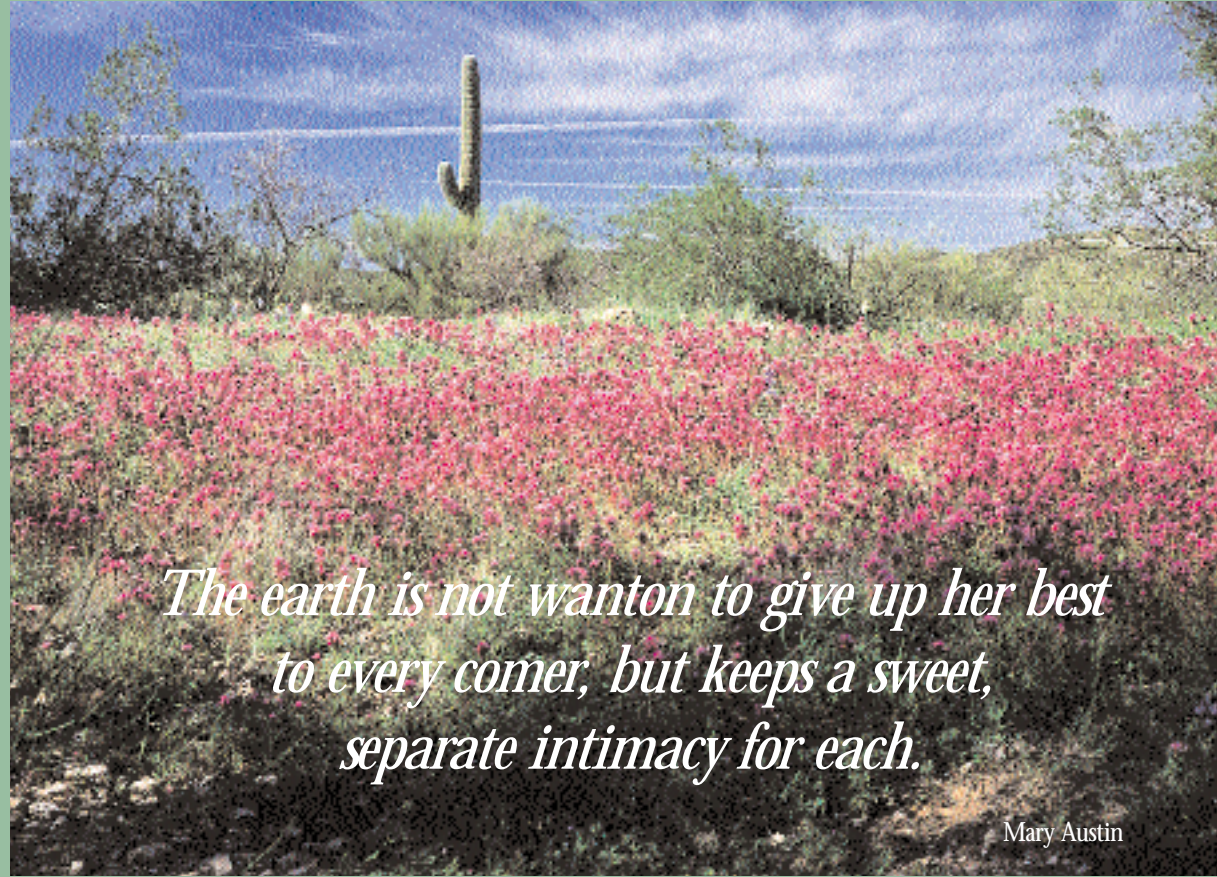


1510 E. Ft. Lowell Road • Tucson, AZ 85719
520.622.3861 • nature.org/arizona

The Nature Conservancy, founded in 1951, is a global nonprofit conservation organization. Its mission is to preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive.



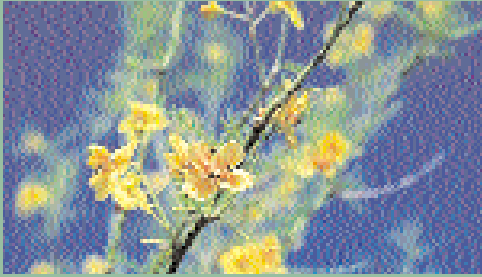
Jim Malins



Mark Dimmitt

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

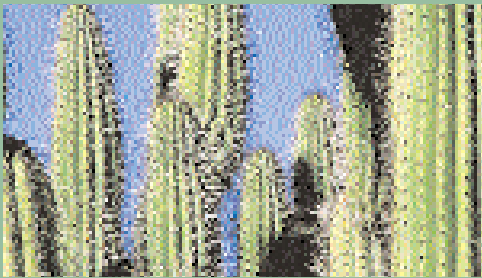
Mary Austin



Jeanne S. Browne



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Rick Daley

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healthy landscapes • vibrant economies • livable communities

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