Special Conservation Report

The Threat that Invasive Weeds and Wildfires Pose to Our North American Desert Biomes PART 2 THE SONORAN SAGUAROS



A lone Saguaro with a

Red-Tailed Hawk nest ensconced in its branches stands among the dead Creosotes of the Vekol Valley. The short grasses and forbs here fueled a low-intensity fire singeing this cactus about two meters up the side of the trunk. The damage was minimal.

> aguaro forests of the Sonoran Desert suffered an unusual series of fires in 2005 much like those that devastated the Joshua Tree woodlands of the Mojave Desert (*Cactus and Succulent Journal*, Nov–Dec 2005). Invasive weeds, by increasing the extent and severity of these natural

wildfires, have begun to tip the ecological balance of North American deserts. Researchers have warned for years of the deleterious combination of invasive weeds and fires and the reduction in desert biodiversity that can be expected once this pattern goes too far, but it was not until 2005 that massive wildfires in both the Sonoran and Mojave Desert ecosystems finally focused broader public attention to the matter.

One might think that the ramifications of fire are virtually identical in both the Sonoran and Mojave Deserts, but there are many differences between the two ecosystems. Here we describe how fires affect the Sonoran Desert ecosystem, focusing mainly upon the Saguaro and its associated nurse plants, such as Ironwood and Palo Verde. In this complex and varied ecosystem, these are definitive species without which many other parts of the Sonoran would fail to function.

The fall and winter of 2004–2005 was exceptionally wet in much of the Sonoran Desert. Abundant moisture fueled the rampant growth of a number of noxious weeds and grasses. The main culprits were the introduced invasive



This Saguaro is doomed to die within a year due to bacterial attack of the burn-damaged tissues. Its base is showing acute necrosis, a consequence of tissue injury caused by intense flames. Swarms of flies are feeding on and breeding in the rotting plant tissue.

Mediterranean grasses (Schismus spp), cheat grasses (Bromus spp), and mustards (Brassica and Sisymbrium spp), along with native annuals such as woolly plantain (Plantago purshii) and fiddleneck (Amsinckia intermedia and A. tessellata). Under this fuel load an unprecedented 300,000 acres of prime Sonoran Desert habitat burned during the 2005 spring and summer wildfire season, mostly within the Arizona Upland and Lower Colorado River subdivisions of the Sonoran Desert. Although some fraction of the annual forb growth that carried these fires was native, it is unlikely that they alone could have fueled them without the help of other, alien species. Research by Matthew Brooks and David Pyke into the associated problems faced by managers of Western public lands is tremendously useful¹.

When Fire Enters the Cactus Forest

When fire rips through a stand of Saguaros, they are affected differently than the Joshua Trees covered in Part 1. Saguaros are much more succulent, and they lack the dried leaves that make yuccas so flammable. Although their spines are capable of burning, the flames they support are small and do not deeply injure the stem tissue, so a mature plant might withstand the passage of fire with only minor scorching as long as there is no other fuel source nearby. In contrast, passage of fire through Joshua Tree (*Yucca brevifolia*) forests results in death rates approaching 100%. Initial death rates are lower in Saguaro stands, but after exposure to high heat cacti become vulnerable to a variety of secondary threats that can kill them years after the original fire².

It is well known that most Saguaros in flat areas, unprotected by large rocks and boulders, are harbored during their early years beneath a nurse plant, such as Foothills Palo Verde (Cercidium microphyllum). Regardless of species, all nurse plants have one function in common: they shelter vulnerable cactus seedlings from the threats of drought, heat, frost and predation. While many Saguaros outlive their nurse plant and end up standing alone in the open, many others remain near a living or dead nurse plant and accumulations of leaf and stem litter, which pose a fire threat that isolated cacti do not face. When such fuels are ignited, the result is a hotter, longer-lasting fire that can cook an unprotected cactus stem.

Saguaros do not have bark in the strictest anatomical sense. Therefore, unlike Ponderosa Pines and Redwoods, which possess a thick, flame-resistant bark, the weathered, corky skin of a Saguaro does little to protect the plant from fire. The Saguaros most likely to survive a fire are ones that stand alone and those on rocky hillsides with low fuel loads.

The Standing Dead

The Vekol Valley in southwestern Maricopa County, Arizona, about 40 km west of Casa Grande, contains fairly dense, nice stands of Saguaros. Unfortunately the Valley has been heavily invaded by weedy grasses, primarily Schismus species. The 6200 acre Vekol Fire blazed through the valley in late May 2005. Two months later many Saguaros were showing signs of dving, even though their tops were still green. Flies swarmed over foul-smelling. necrotic tissue at the bases of plants that from a distance looked healthy (soot-covered trunks notwithstanding). These flies, which resemble small house flies and fruit flies, are of several species evolved to breed in decaying cactus flesh. The future looks bright for these flies, as tens of thousands of Saguaros, barrels and other cacti will die in the coming years.

Unlike burned Joshua Trees, scorched Saguaros can look healthy for months or years after a fire. Many plants do not look like they are dying, especially if they are still green at the top, but a deeply wounded cactus merely staves off bacterial infec-

tion for a while, eventually being overcome by a sort of gangrene that spreads through its trunk. My observations were too soon after the event to determine how many cacti will be killed by the fire, but the final decline had already begun for many plants. Heavily-damaged plants will probably die within a few months, while others may hang on for several years before succumbing to drought, frost or wind.

The Vekol Fire occurred in fairly arid, Lower Colorado Desert terrain, but most of the fires in the lower deserts were relatively small in comparison to other fires in both the Mojave and



This swath of Sonoran Desert in the McDowell Sonoran Preserve near Scottsdale, Arizona, was burned around 1998; seven years later it has not fully recovered. Many species that ought to be abundant are scarce or missing.

Upper Sonoran deserts, generally burning a few thousand acres at a time. The Cave Creek Fire, in contrast, burned nearly 250,000 acres north and east of Phoenix in late June 2005. This fire started out as a complex of nearly a dozen widelyseparated blazes ignited by dry thunderstorms on June 21; these eventually merged to become the second-largest fire in Arizona's recorded history. It took nearly three weeks to extinguish and was additionally unprecedented for the fact that it consumed so much desert—as much as 50% was located in a formerly pristine Upland Sonoran biome.



▲ Scenes like this collapsed Saguaro will be common throughout groves that burned.

The region northeast of Phoenix is noteworthy for its large populations of massive Saguaro cacti and high densities of many other Sonoran species supported by abundant bi-seasonal rainfall (to 15" or more). But this lush vegetation comes with a risk; fires can claim vast swaths of this desert and quickly convert it into something resembling chaparral. Near Bartlett Lake on the Verde River northeast of Cave Creek is a desert full of large Saguaros, Soaptree Yuccas (Yucca elata). massive Red Barrel Cacti, super-sized Ocotillos (Fouquieria splendens), many Opuntia species, and large numbers of Palo Verde and Mesquite trees to serve as nurse plants. Unfortunately, all this abundant native vegetation, combined with half-meter tall stands of weedy grasses, mustards, and other forbs, supported much more intense, wide-ranging fires than occurred in areas like the Vekol Valley.

I visited the Cave Creek area on August 5, 2005, about six weeks after the blaze. The summer monsoon arrived late in 2005, but rainfall in the burned areas had already promoted a veneer of green sprouts at the base of the Catelaw Acacias (Acacia greggii), Jojobas (Simmondsia chinensis) and other shrubs, which helped to soften the immediate sense of devastation. But while the crown-sprouting shrubs were showing signs of new growth, tan areas (indicating spine-burned tissue) extended up the sides of the Saguaros. In many cases, this scabbing reached up into the branches of even the largest plants, and in a few examples affected the apex of the main stem. The

▼ A southward-leaning Red Barrel

(aka Compass Barrel, *Ferocactus cylindraceus*) that escaped burning in the Vekol Valley. The unburned forb and grass cover is presumably typical or of or thinner than what existed prior to the fire. The open areas between shrubs harbor woolly plantain, and thick stands of Mediterranean Grass fill spaces under and around small shrub canopies. Even this thin, short fuel was able to carry fire across the desert.





fire must have been intense here.

This area of desert was also home to a substantial number of unusually massive Red Barrels. In my trek through the hills and washes surrounding Bartlett Lake I discovered many barrels nearly two meters tall, well over a century in age, and weighing 100 to 150 kg. Many had all of their spines burned off and were dying.

It may look like the desert is recovering and that most of the plants will revive, and while many of the non-succulents may return, the attrition rates of the Saguaros still standing will require years to assess. If this area suffers a second fire any time in the next few decades, most of the remaining cacti will be eliminated, and the transition of this part of the Sonoran Desert into impoverished weedy savanna will be well underway.

From a population standpoint, plants can survive a setback as long as enough mature individuals are able to flower and set seed to keep the genetic diversity high. Some of the semi-succulent plants, such as the Banana Yuccas (*Yucca baccata*) will be able to recover from subterranean rhizomes. In fact, some had managed to become almost 30 cm tall in just six weeks using the water and starch reserves of their thick, underground stolons. *Yucca elata* is also capable

This sad scene of dying Saguaros and Soaptree Yuccas typify the damage done in the Cave Creek Fire.

▼ The Arizona Upland Sonoran Desert near Cave Creek, Arizona, here in a pristine state, is thick with native shrubs and invasive weeds, which together carried the state's second-largest fire across 250,000 acres in 2005.



of resprouting from the rootstock, although it will be several decades before the plants achieve the stature that they had prior to the fire. These two vegetatively-reproductive yuccas will likely fare better than Saguaros, Barrels and Joshua Trees, which can only come back from seed.

Nursing The Future

How will the succulent populations of the Sonoran Desert fare after these fires? As with most things ecological, the answer is complex. I believe there are two main factors to consider: First is the immediate death toll: Will enough plants survive to reestablish the populations? Second is recovery speed for seedlings and the rebounding of populations to their original levels.

Most desert perennials are unable to establish themselves in open sun and bare soil; they die

► A spectacular, 2.2-meter tall Red Barrel Cactus denuded by the Cave Creek Fire. This unusual specimen is perhaps 150–200 years old and, putting out three branches, is doing a very rare thing in the genus *Ferocactus*. Even if it survives the loss of all of its spines, it is permanently disfigured.

▼ Banana Yuccas are capable of relatively quick regeneration from their subterranean root systems, unlike the small Saguaro in the background.



in the heat of summer or are promptly eaten. One effect of desert fire is that it removes most nurse plants needed by cacti fduring their tender seedling years. Even if there is a supply of seeds present in the soil, the ability of those seeds to survive after germination will be compromised by the dearth of nurse plants, which themselves often take many years to survive unprotected.

Xeric trees like the Foothills Palo Verde are as vulnerable to fire as the succulents they harbor, and are generally as slow to recover. These slowgrowing desert denizens are of modest-stature; at four to five meters tall are already 100 or more years old. Palo Verdes have a thin, photosynthetic, green bark, and as a water-conserving measure, they dispense with leaves for most of the year allowing the green bark to assume photosynthetic responsibilities. They have as little



fire-resistance as Saguaros because the cambium layer beneath this thin-barked trunk is killed when even small fires pass beneath them. In the research performed by Cave and Patten on both natural wildfires and controlled burns in the Upland Sonoran Desert east of Phoenix, nine months after a fire 73% of Palo Verde trees had died². Similar death rates, they note, have been observed in other studies.

Another important Sonoran nurse plant is the Ironwood (Olneva tesota), whose wood is among the heaviest and densest known. These trees are exceptionally slow-growing and longlived and can exceed 1000 years in age. Their bark seems to be thicker and slightly more fireresistant than the Palo Verde's, but there was not much to see between two extremes of damage in the burned Ironwoods. Those with minor damage were sprouting new branches less than two months after the fire had come and gone. What remained of the rest was a few branches spread radially around a 15 cm-deep depression filled with fine, white ashes probably caused by the volume reduction of the underlying leaf duff and possibly the complete burning of the roots. Leaf and branch litter accumulated beneath older trees may have spelled the difference between living and cremated individuals. Ironwood is a favored fuel for charcoal and campfires precisely because it burns hot and clean with little smoke or soot. This might explain the totally consumed ironwoods (and similarly, Mesquites) while the Palo Verdes were generally killed, but not burned to the ground.

Some Palo Verde trees at the Cave Creek Fire were starting to resprout from at or below ground level. Mesquite trees (*Prosopis* spp) will readily resprout from their bases. Ironwoods can also resprout from the trunks and root crowns, but only if the crowns weren't burned down into the soil. Root-sprouting is beneficial for more rapid population recovery than seed reproduction would be, and hopefully it will help alleviate the severe reduction in the tree and shrub component of these deserts.

ess extensive fires have occurred before in the Sonoran Desert. Several fires in the 1990s around Cave Creek and North Scottsdale burned several thousand acres. Ten years later we have an example of what to expect with regard to the fires of 2005. There are almost

▼ Thin-barked Palo Verde trees are

extremely susceptible to death by fire, like this partially-burned specimen. This, along with the Saguaro, is perhaps the most critical associate species in defining the Sonoran Desert. The tree shown here is unusual in that only the lower portions of the bark have died and turned brown; the crown portions of most other observed Palo Verdes were completely dead, although some will manage to resprout from the bases.





▲ Ironwood trees are important members of the Sonoran Desert ecosystem, and many experienced being burned to the ground with NO hope of regeneration.

no large Palo Verde trees in previously burned areas, although there are some resprouting from roots that will take another 10 to 15 years to support nesting birds. Other plants are utterly missing, from Ocotillos to Opuntias to a diverse array of small shrubs. The Saguaro population appears to have been reduced (visually compared to nearby sites) by about 50-75% from former levels. The Saguaros that have survived are middle-aged, with both juveniles and grand old plants conspicuously absent. Those that remain show extensive scarring, cracking and splitting where the epidermis was scorched-alive today after their experience with fire, but can they survive a second? Simple observation bears out what research has shown: the entire structure and species composition of the desert community changes after fire, generally becoming less diverse².

here are two primary seed sources available to regenerate burned areas: that stored in the soil bank awaiting germination and that available from mature plants. The soil seed bank is viable and necessary for the recovery of perennials, but probably less able to regenerate decimated populations than having nearby populations of live plants to serve as a fresh and abundant source. Affected areas closest to healthy populations of plants are more likely to be reseeded and should recover faster.

For instance, the burn pattern of the Vekol Fire was linear, narrow and long, running across the valley and up against the foothills of the Maricopa Mountains. Most areas are no more than two km from undamaged populations of all the Sonoran Desert plants that comprise the local community, and many areas are less than 300 m from thick stands of all the major plants that live there. If fire can be suppressed in future years and a solution found for the weeds that spur them, long-term recovery prospects look fairly good for the patchy areas burned in the Vekol Valley. This might not be the case for the more extensively burned areas of the Cave Creek Fire, where large swaths of desert have been compromised by more intense flames and are now isolated from healthy populations of plants and animals.

An Urgent Call For Change

We cannot blithely assume we may continue on our current path without genuinely accounting for the true environmental consequences of our behaviors. Recent human activities are largely responsible for individual species extinctions and the loss of entire ecosystems that support them. This cannot continue if we want to save most of our unique and precious fellow creatures from extinction. For where they go, we will ultimately follow.

Unlike the exotic species we spread, we have some control over our behavior and activities. We need to act responsibly to fix the problems we have created. If we do not rise to the occasion, the least we will see is the loss of many of the most wonderful species we share this earth with in favor of a planet full of weedy plants, weedy animals and homogeneous ideas. A world without biotic diversity is a world hardly worth living in.

REFERENCES

1 BROOKS ML, PYKE DA. 2001. Invasive Plants and Fire in the Deserts of North America. *In* KEM Galley and TP Wilson (eds). Proceedings of the Invasive Species Workshop: the Role of Fire in the Control and Spread of Invasive Species. Fire Conference 2000: the First National Congress on Fire Ecology, Prevention, and Management. Miscellaneous Publication No. 11, Tall Timbers Research Station, Tallahassee, FL. **2** CAVE GH, PATTEN DT. 1984. Short-term Vegetation Responses to Fire in the Upper Sonoran Desert. *Journal of Range Management* 37 (6): 1–6.