Special Conservation Report

Nevadagascar?

The Threat that Invasive Weeds and Wildfires Pose to our North American Desert Biomes

Part 1: The Mojave Desert and Joshua Tree woodlands

JAN EMMING

It is ironic that, while the well-used term "desertification" of semiarid grasslands and savannas like those of sub-Saharan Africa is taken correctly to mean a decline of the native ecosystem into barren desert, something resembling the reverse is happening in North America. We are seeing diverse native desert communities suffering a decline into degraded weedy grasslands with but a fraction of their former diversity. In fact, many ecosystems worldwide (both wet and dry) are experiencing a shift away from diverse native floras and being replaced by similar-looking, though highly despoiled habitats with a relatively few species adapted to human disturbance: weeds.

In the North American West and Southwest, a heavy infestation of invasive alien weeds, spurred by the very wet winter of 2004–05, have fueled unprecedented wildfires in our deserts and semiarid regions, threatening the survival of slow-growing cactus and succuelnt species not adapted to burning. The problem is only likely to get worse unless controls can be found for the most problematic weeds.

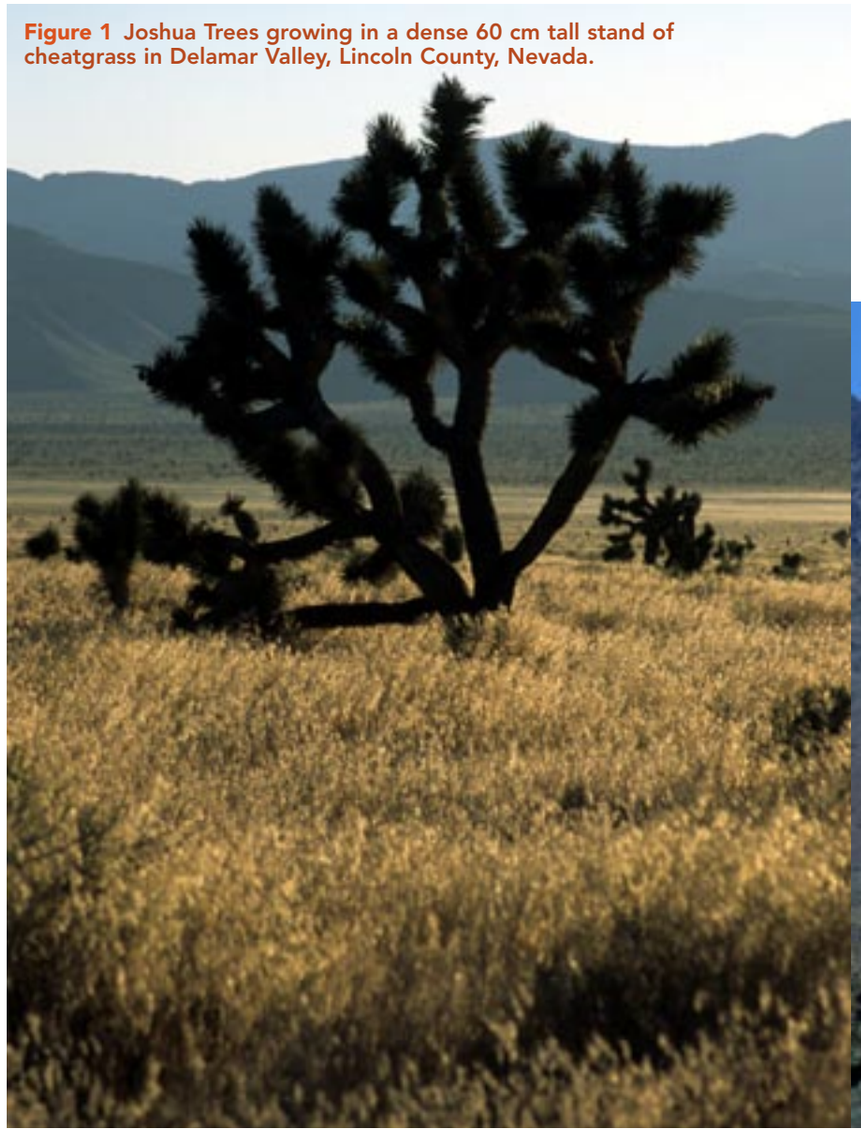

Figure 1 Joshua Trees growing in a dense 60 cm tall stand of cheatgrass in Delamar Valley, Lincoln County, Nevada.

Madagascar is well-known

to naturalists and biologists all over the globe for its rich biotic diversity and its marvelous array of unique and endemic plants and animals. Of course lovers of succulent and caudiciform plants are familiar with many natives of this fantastic land. Some of the most charismatic and widely-appreciated succulent and xeric plants are native to this country, including many pachypodiums, euphorbias, aloes, and seven of the eight species of baobab trees in the genus *Adansonia.* These plants need little introduction to most succulentists, and certain representatives of these genera are even recognized by novice gardeners as houseplants.

Located primarily in the tropical and subtropical arid and semiarid zones that sandwich the wet equatorial tropics (mainly from approximately 25 to 40 degrees north and south in latitude), much of Madagascar was covered before the arrival of humans with a fantastically diverse mix of dry tropical forest, seasonally arid deciduous woodland, and near-desert scrub located primarily in the western half of the island. The eastern half contains an equally rich and varied mix of other habitat types less conducive to succulents including belts of wet tropical forest, cloud forest, mangrove swamp, and evergreen mountain forest.

Unlike most of earth's large landmasses, Madagascar was populated by humans only 1500 years ago. Groups of Indo-Malayan, African and Arabian peoples arrived over the centuries beginning about 500 AD, and each successive wave took its toll upon the island's environment. Many of the largest and most unusual animals were quickly hunted into extinction, and the remaining species of fauna are in most cases suffering severely reduced populations and/or near extinction everywhere they come into contact with humanity.

Naturally, the plants have suffered badly since the arrival of humankind as well. A social system developed among the newly-arrived Malagasy peoples that values the possession of large numbers of zebu cattle as a measure of social status and personal wealth. As such, a regime of regular,

Figure 2 Joshua Tree woodland, western slope of Delamar Mountains, Lincoln County, Nevada.

Figure 3 (Top) View of the Delamar Fire in the distant foothills of the Delamar Mountains. Fire-carrying Cheatgrass in the foreground Joshua Tree forest is so thick that only the tops of the native blackbrush and sagebrush shrubs are visible amongst the grasses.

Figure 4 (Bottom) A sweep of (former) Joshua Tree forest burned near Lime Mountain, Nevada east to the Beaver Dam Mountains, Utah.

and in most cases virtually annual, fires has been implemented to encourage the growth of grasses palatable to cattle. This has resulted in the near total displacement of forests across most of the island by non-native savanna. The gloriously diverse natural ecosystem of Madagascar that once existed is today little more than an impoverished selection of a few non-native grasses interspersed with a drastically reduced selection of fire-tolerant native plants. This exchange of one natural ecosystem for another far less diverse one is especially apparent in the semiarid and seasonally dry zones more conducive to cattle-raising[2].

Of course, our cultural love affair with the cowboy myth notwithstanding, America's use of cattle has little to do with the destruction by fire of the North American Deserts. So why are fires threatening ecosystems here?

Figure 5 (Top) Destruction by fire of a high-density, mature, centuries-old grove of Joshua Trees. Although it is hard to date the precise age of Joshua Trees, based upon average annual growth rates the largest of these trees are at least 200–300 years old.

Figure 6 (Bottom) The foothills of the Beaver Dam Mountain Range in southwestern Washington County, Utah, sport a dust devil that vacuums up the ash remaining from the Westside Fire complex, which burned through the region in late June, 2005. The cacti are mainly Buckhorn Chollas, and the other yuccas are Banana Yuccas.

Figure 7 (Top) A collection of Red Barrel Cacti, including a rare crested specimen, killed by the passage of the 350,000 acre Duzak Fire near Lime Mountain in Lincoln County, Nevada.

Figure 8 (Bottom) Steep, succulent-diverse limestone hills above Bull Valley Wash near Upper Lime Mountain Well in Lincoln County, Nevada. Succulents in this photo include Red Barrel Cactus, Engelmann Hedgehog, Buckhorn Cholla and the flowering spikes of Utah Agave.

Fires are not a natural part of most desert communities worldwide. In fact, if there are any desert biomes on Earth that experience widespread fires on a regular basis, I am unaware of them. This is counterintuitive, because deserts are such dry environments; one would think they ought to be extremely fire-prone. But it is precisely the aridity of deserts that prevents them from experiencing fires. The native vegetation is typically too sparse to support the spread of flames from one plant to another. Thus, a wetter, better-vegetated ecological community such as chaparral, pinon-juniper scrub, or montane evergreen forest is more prone to being periodically scorched than a desert normally ever would be.

Many non-desert life zones require periodic burning of low to moderate intensity for best ecological health and optimal diversity. Some plants in these communities cannot reproduce *without* a scorching by fire, and many of them have developed strategies to live through and even to benefit from fire and the years immediately afterward one. But none of these qualities is shared by most desert plants or ecosystems. The large majority of succulent plants cannot withstand even a mild burning, much less an outright immolation, and their populations would suffer tremendously for many decades if fire were to ever rear its orange head in the deserts of North America.

But fires *have* become a regular feature in all four of the North American deserts. How did this happen? The answer lies primarily with non-native, invasive weeds, which arrived as a side effect of human activity. There is a handful of aggressive species with an uncanny ability to rapidly reproduce and spread into untouched terrain. There are two main reasons the term *invasive* is used to describe these plants. The first is that they spread unaided by human effort. The second is that they have the capacity to restructure the functioning of the ecosystem to the detriment of most natives. While not all aliens are invasive (some assimilate well in new habitats to increase biodiversity), these weeds

Figure 9 A grove of Joshua Trees, possibly of the variant *Yucca brevifolia* var *jaegeriana*, stands at the upper limits of Joshua Tree habitat as it transitions into Pinon-Juniper woodland on a hill in the Bull Valley Wash drainage of Nevada. Such plants might be able to recover from fire from the root zone, unlike most lower-altitude, true desert Joshua Trees, which generally reproduce from seed.

are colonizing desert ecosystems, filling in the blank spaces between plants, and promoting large-scale fires in a community entirely unable to cope with such hazards.

These culprit species in the American Southwest include grasses such as Cheatgrass (*Bromus tectorum*), Red Brome Grass (*B. rubens*), Buffelgrass (*Pennisetum ciliare*), Fountain Grass (*P. setaceum*) and Mediterranean grasses (*Schismus barbatus* and *S. arabicus*) along with weedy annual forbs (broad leaved herbs other than grasses) such as Red-leaved Filaree (*Erodium cicutarium*), Sahara Mustard (*Brassica tournefortii*), several knapweeds and Yellow Star Thistle (*Centaurea* spp) and Oriental Hedge Mustard (*Sisymbrium orientale*). All of these plants are non-native (primarily African and Eurasian species), and all have become firmly established in the desert habitats of the Southwest. Some have been here for 100 or more years while others are more recent introductions, they are spreading unchecked into wild areas that are, in many cases, far from human activity, and they all pose a threat to native ecological functioning and integrity.

There are at least two main dangers associated with invasive weeds: First, they simply crowd and out-compete native species or their seedlings for limited water and nutrient resources by germinating earlier, faster, or more densely than natives can with the effect of reducing native plant density and diversity. For instance, once glorious displays of annual desert wildflowers like Mexican Goldpoppy, Sand Verbena, Evening Primrose, Lupine, and Owl's Clover have diminished in recent years. And while adult perennial species can survive the onslaught from annual weeds, seedlings may have trouble becoming established.

The second and graver threat is fire. September 2004 to March 2005 was one of the wettest periods on record in the southwest. The Mojave Desert regions, spanning from southeastern California through south central Nevada to southwestern Utah and northwestern Arizona, received two to three times their normal annual rainfall in that seven month period. Such wet seasons are critical to desert health, as they tend to be the times

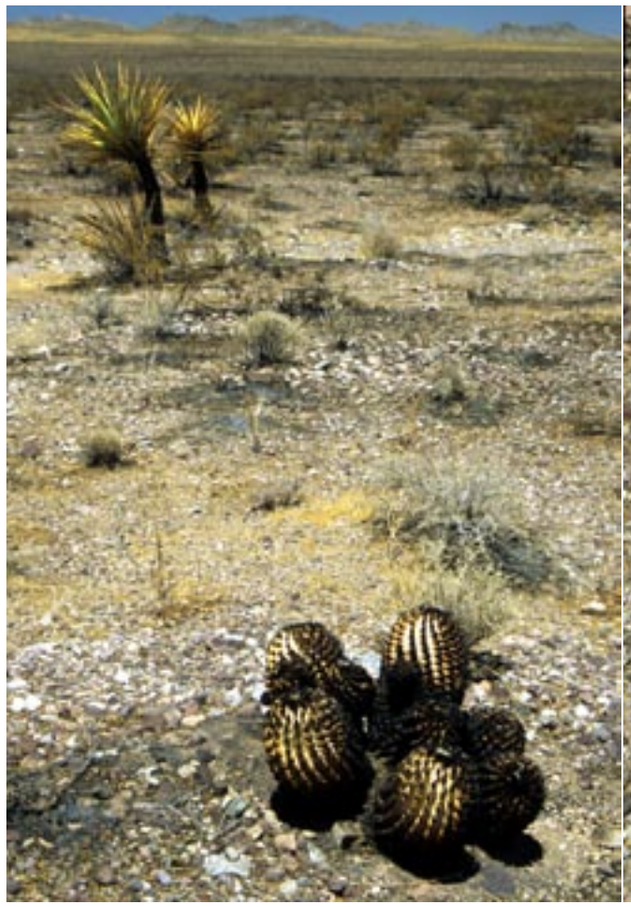

Figure 10 (Left) A ruined specimen of the uncommon Many-headed Barrel Cactus stands alongside a clump of burnt Mojave Yuccas. The Perkins Fire burned through this region of the Black Mountains of northwestern Arizona, fueled primarily by Mediterranean grasses.

Figure 11 (Right) This partially-burned specimen of *Echinocactus polycephalus* faces an uncertain future. It is not clear whether a specimen suffering a partial burning will be able to survive.

when most of the long-lived, slow-to-reproduce succulents and perennial trees replicate. But one of the drawbacks to a wet year these days is that it also results in a bumper-crop of exotic weeds.

Cheatgrass and Red Brome

are closely related and similar to each other in appearance, lifestyle, and environmental impact, and they have become the worst invaders of the Mojave in recent decades. Cheatgrass prefers the colder Great Basin Desert valleys and mountain slopes, where it has come to dominate millions of acres of Sagebrush desert, Single-leaf Pinon Pine forests, and Juniper woodlands. These native ecosystems are being converted wholesale into a virtual monoculture of this weed under a regime of fires that recurs every a few years instead of the decades normal for the Great Basin steppes. Red Brome is redder in color and prefers the more arid, lower-elevation reaches of the Mojave Desert, though the species overlap nearly everywhere they occur.

Cheatgrass derives its common name from the way that it "cheats" the rangeland and grazing livestock of more palatable, nutritious forage plants by out-competing them and by carrying frequent fires that kill adult plants and prevent the re-establishment of seedlings. Cheatgrasse is eaten to some extent by both livestock and wildlife while still green and succulent, but their rapid-maturation, cool-season life cycle ends abruptly as the weather warms up in spring. Cheatgrass usually dies and dries out in the months between March and May, months earlier than native plants, which don't die back until the height of summer, or even fall, extending the productive use of rangeland for all manner of herbivores. This quick-to-grow, quick-to-die, aggressively competitive habit leaves little on the land to eat save for low nutrient, highly flammable, dry stems.

The Joshua Tree, *Yucca brevifolia*,

is the signature plant of the Mojave Desert. Fig 1 shows a thick, 60 cm tall cover of Cheatgrass on the floor of the Delamar Valley at an altitude of 1520 m in south-central Lincoln County, Nevada. The Delamar Valley is located in a transition zone between true Mojave Desert scrub to the south and the Great Basin Desert to the north, and it possesses a splendid stand of Joshua Trees. Here the valley soils become progressively finer and siltier to the west, resulting in the diminishment of the Joshua Trees in the distance as the valley cedes to a dry lake bed. Looking in the opposite direction up the slopes to the east, the beauty and diversity of the Delamar Valley stand of Joshua Trees becomes more apparent (Fig 2). Many of the trees are 6–8 m tall and have anywhere from 50 to 200 branches that form lush, rounded crowns. The native understory of the woodland is a mix of woody shrubs and cacti, which include a red-dish-spined variant of the Silver-and-Gold Cholla (*Opuntia echinocarpa*), Grizzly-bear Prickly Pear (*Opuntia erinacea*), and Banana Yucca (*Yucca baccata*). Note how the Joshua Tree woodland gradually rises up the slopes of the Delamar Range until the small-to mid-sized trees of the Single-leaf Pinon Pine (*Pinus monophylla*) and Juniper (*Juniperus osteosperma* and *J. monosperma*) forest becomes predominant.

The very presence of this unique, scenic and diverse Joshua Tree woodland is direly threatened by the thick understory of Cheatgrass (Fig 3). This view shows an extraordinary and unprecedented density of weed cover and a fire-burned area in the background foothills. The Joshua-forested lower slopes were charred in the so-called Delamar Fire, which was sparked by lightning in late June, 2005, and burned approximately 77,000 acres in the Delamar Mountains over about two weeks before being contained. While much of the burned area was the more fire-resilient Pinon-Juniper woodland at higher elevations, a significant fraction of it was Joshua Tree woodland.

Any ecological community can withstand the loss of an occasional individual without threatening the overall stability of the community, and individual fire-adapted plants may live or die when burned, but their populations rebound. Joshua Trees have been struck by lightning during sum-

Figure 12 The magnificent Tule Desert Joshua Trees of Lincoln County, Nevada. This extensive but little-known stand of Joshua Trees is on public lands administered by the BLM; this is an immensely beautiful, dense population highly representative of Mojave Desert diversity. Unfortunately, about half of the Tule Desert Joshua Tree area burned in the 350,000 acre Duzak Fire that swept the region, including the strip in the background running across the base of Blue Nose Peak in the rugged Clover Mountains. On the bright side, about half did not burn…yet; cheatgrass fuel loads remain very high in unburned section of the forest.

mer storms for untold millennia, and when one does suffer a strike, it bursts into flames, burns fiercely, and dies; the fire unable to spread to surrounding plants. I have witnessed the effects of this phenomenon several times in my journeys through the Joshua Tree forests of the Mojave. But with a covering of Cheatgrass, fire can now spread throughout the Joshua forest, and Joshua Tree populations become vulnerable to even the mildest of rangeland fires, because a dead, highly flammable leaf skirt commonly runs near or all the way to the ground on even large plants, providing a ladder upon which even a small, creeping fire can gain access to the crown. In these recent wildfires, fire reached into the crown of virtually every tree, killing them. Their slow growth rates ensure that recovery of a burned Joshua Tree forest will be measured in decades or, more probably, centuries.

Figure 13 Nevadagascar? The aftermath of the Duzak Fire in a once superlative stand of Joshua Trees in the Tule Springs Hills of Lincoln County, Nevada.

A record-setting wet winter

led to an equally record-setting fire season, with the large majority of the damage occurring in a holocaustic two-week period from June 21 to about July 4, 2005. A cold front that passed through the northeastern Mojave and the southern Great Basin Deserts spawned a series of fast-moving, dry thunderstorms with lightning that ignited at least 25 fires spread out over a large region of Arizona, Utah and Nevada.

This dangerous outbreak of multiple fires, many of which were burning in remote, rugged terrain far from inhabited areas, utterly overwhelmed the ability of firefighting crews to deal with the crisis; remote fires were necessarily left unattended. June 23–25 brought strong southwest winds and temperatures in the high 90s to low 100s across the region, causing an overnight quadrupling of areal fire coverage, totally outstripping the ability of fire crews to mount an effective response.

In all, nearly one million acres of desert and woodland burned over those two weeks, an area larger than the state of Rhode Island. Figure 4 illustrates a small cluster of burned Red Barrel Cactus (*Ferocactus cylindraceus*) and Banana Yuccas in the foreground of a blackened region stretching from my position about 8 km west of

Figure 14 A burned-out BLM sign marks the Nevada-Utah state line. The two states share parts of the Mojave Desert along with Arizona and California; all share a common ecological fate of drastically diminished natural value unless biological controls for the weeds promoting such devastating fires can be found.

the Utah–Nevada state line, about 40 km east to the crest of the scorched Beaver Dam Mountains of extreme southwestern Washington County, Utah. This area was covered with a high-density, ancient Joshua Tree forest with many large, 300–500 year old trees (Fig 5). The forest may never recover here.

The destructive presence

of annually-renewable, fire-prone Cheatgrass might well result in a Nevadan version of what has happened to Madagascar since the arrival of humans there. The Delamar Valley Joshua Tree groves were relatively fortunate in that the majority of the forest was not torched, but the western slopes of the Beaver Dam Mountains in Utah, once covered with a high-quality Joshua Tree woodland with an associated dozen or so additional species of succulents, was almost entirely burned in June 2005 by the Westside Fire complex that torched some 30,000 acres (Fig 6).

When I went to see this environmental catastrophe for myself, I was shocked to see how extensive the burned areas were. Conservatively assuming that out of nearly a million burned acres, only 10% was Joshua Tree woodland, a minimum of 100,000 acres of Joshua Tree Forest met its fate in these fires (not counting other fires elsewhere in Nevada or the Mojave Desert). The actual area of Joshua woodland that suffered fire is probably two to three times that figure, and the total number of destroyed Joshua Trees must number in the millions.

Some of the affected areas of Joshua forest were comprised of a variant known as *Yucca brevifolia* var *jaegeriana*, characterized by several differences from variety *brevifolia,* including higher-altitude adaptations (to 1830 m) such as a generally shorter stature of not much more than 3–4 m, shorter leaves and tighter leaf rosettes, and a multiply-branched habit that results in densely-rounded crowns on attractive, compact plants. Plants of var *jaegeriana* also commonly form suckers from underground rhizomes, forming groves (Fig 9). These characteristics are most frequently found among Joshuas that grow interspersed within Pinon–Juniper forest associates at the upper elevational limits of their range. It could be argued that the root-suckering trait offers a selective advantage for Joshua Trees that are situated in a place that occasionally does see fire. It will be interesting to see if, in a few years,

some of these groves manage to regenerate from root suckers. Of course the regeneration and subsequent long-term survival of these trees is predicated upon the notion that fires are not too frequent, a matter that is in serious doubt.

The Red Barrel Cactus (*Ferocactus cylindraceus*) is abundant and widespread in both the Mojave and the Sonoran Deserts, and like most other succulents, it is not fire-resistant. I have seen Red Barrels survive the loss of their spines by fire and regrow new ones from the top of the plant, but they remain permanently disfigured and become vulnerable to predation by insects, rodents and disease once the green photosynthetic tissue is damaged and the spiny armature removed.

Figure 7 shows a cluster of Red Barrels after the passage of Nevada's 350,000-acre Duzak Fire. These plants were located in the upper transition zone between desert and Pinon–Juniper forest, and the fire must have been very intense here thanks to the presence of the flammable juniper trees, the skeletons of which are scattered across the hills. None of cacti are likely to recover; the fire's heat was probably far too extreme, parboiling plant tissues too deep to allow for any regrowth. This sad scene is particularly poignant to lovers of crested and monstrose plants, as it shows an extremely rare cristate barrel denuded by fire.

Even more surprising than the cooked cacti was how even the rockiest, steepest and most thinly-vegetated slopes were also burned. The steep and precipitous limestone hills lining the course of the large Bull Valley Wash (Fig 8) near Lime Mountain, Nevada shows how little Cheatgrass is required to set off fires and kill succulent plants and other desert denizens. Not every cactus is burned in this view, but note how many are, and how little fuel was required. Succulent plants here include Red Barrel Cactus, Buckhorn Cholla, Silver-and-Gold Cholla, Banana Yucca, Joshua Tree, Mojave Yucca (*Yucca schidigera*), Variable-Spined Engelmann's Hedgehog (*Echinocereus engelmannii* ssp *variegatus*), Mojave Claret-Cup Hedgehog (*E. triglochidiatus* ssp *mojavensis*), Beehive Cactus (*Coryphantha vivipara*), Fishhook Cactus (*Mammillaria tetrancistra*), Beavertail Prickly Pear (*Opuntia basilaris*), Grizzly Bear Prickly Pear (*O. erinacea*), Brown-Spined Prickly Pear (*O. phaeacantha*) and Utah Agave (*Agave utahensis* var *nevadensis*). Only a thin filigree of Cheatgrass not more than 15 cm tall was poking out of the crevices of the limestone rocks on this hill. Yet it managed to burn. Steep and rocky hills, home to the largest diversity of smaller succulents, are normally thought safe from burning. But the devastating combination of wind and weeds proved this theory wrong.

It is unclear whether the relatively low intensity of the burning suffered by the plants on hills like this one will allow them to recover and reproduce, but their chances of long-term survival alongside Cheatgrass is minimal. The plants might be able to survive one low-intensity burning, but most are unlikely to survive repeated fires. A follow-up visit to the region in a year or two will provide a better sense of what died, what might recover, and what time frame will be required for regeneration of the habitat.

The Many-headed Barrel Cactus (*Echinocactus polycephalus*; Figs 10, 11) is a near-endemic to the Mojave Desert found in small, patchy, discontinuous populations widely scattered across desert slopes. Though fairly widespread, this species is particularly vulnerable to weed-carried fires, as it is nowhere common; additionally, it is exceptionally slow growing and dislikes cultivation, preferring the rigors of the desert to the pampering of a greenhouse.

Figure 10 shows a ten-headed specimen alongside two Mojave Yuccas that were burned out in the Perkins Fire, which smoked 19,000 acres of the modest-elevation Black Mountains in northwestern Arizona. This terrain near the Lower Colorado River Valley is an arid desert, almost all of it under 1225 m, which normally does not burn. A month after this fire occurred an additional 13,000 acres were burned nearby in the Twin Mills Fire. This sort of patchwork of fires could destroy these desert ecosystems over the next decade or two, because fires don't have to cover hundreds of thousands of acres at a time to wreak havoc; the aggregate effect of many smaller ones won't be any less damaging.

The future of this species looks grim as long as fires occur anywhere in its range. There were only a few dozen plants in this population, and all but a single partially-burned one (Fig 11) were completely devastated. Even if that individual manages to survive, as the lone survivor its reproductive future has probably been ruined. This population has now been effectively eliminated unless seeds in the soil can bring it back. Even if the species does not become wholly extinct, a *de facto* ecological extinction may well occur. Just as bison are not extinct, their ecosystem—free-roaming herds of millions across the sweep of the Great Plains—is. There is now a serious risk of ecological extinction for Joshua Tree woodlands and other Mojave Desert ecosystems.

In the case of the Perkins Fire, the main fire-carrying culprit was Mediterranean Grass, probably *Schismus barbatus*. This species is much shorter than full-grown Cheatgrass, reaching no more than 20 cm, but its density can be amazing, with many thousands of tightly-packed plants per square meter in the worst infestations. When green, Mediterranean Grass looks just like a neatly-mowed lawn. When dried out and gold, it lends the entire desert floor a blond color not unlike wheat stubble on the prairie. And when burned, it leaves behind an ashy-gray and black desert landscape that may never return to normal. I was once under the impression that short grasses and thin veils of Cheatgrass on steep and stony hills would not be able to carry large fires through the desert countryside. I was wrong.

The fires that occurred in 2005 are without precedent in the North American deserts. The extraordinary acreage burned, the high remaining fuel loads in unburned sections, and the potential for further invasion of the weeds responsible bode poorly for the Mojave Desert and its unique, slow-growing denizens. The potential for barrel cactus recovery after losing their spines, the regeneration of certain Joshua Trees from the root system, and the rebounding of seedlings and their nurse plants will all need to be assessed after some time has passed, but how much longer can majestic Joshua Tree forests like the one in the Delamar Valley or the Tule Desert (Fig 12) survive when the pass of a single afternoon wildfire can undo the work of centuries? Will the fate that has befallen Madagascar afflict Nevada (Fig 13)? Heavy infestations of Cheatgrass, Mediterranean Grass or any of the other common fire-carrying weeds (Fig 14) speaks volumes about the future of these ecosystems.

For more information and updates, visit www.burningdeserts.org.