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& Our Regular Features

Helicteres baruensis. La Balandrona. *Photo courtesy José Jesús Sánchez-Escalante.*

The Desert Edge: Flora and Ethnobotany of the Guaymas Region of Sonora, Mexico

by Richard Stephen Felger[1], Susan Davis Carnahan[2], José Jesús Sánchez-Escalante[3], Michael Bogan[4], Alberto Búrquez[5], and Felipe S. Molina[6]

A place of edges, a place of ecotones. Sky, sea, and desert give way to outposts of the tropics. Brown and parched during the long dry seasons and green when it rains. The sea is edged in halophytes and stunted mangroves. Spinescent desert spans most of the land, while riparian canyons host tropical trees and palm oases. Soil moisture and maritime dew choreograph the plants and animals that depend on them.

Sierra El Aguaje is the core flora area—rough mountains, riparian canyons, bajadas, and shores designated in 1937 as *Reserva Cajón del Diablo* but without legal status today. Our flora area extends from the Río Sonora mouth near Tastiota southward to the Río Yaqui and inland

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President's Note *by Douglas Ripley* jdougripley@gmail.com

Welcome to the Summer issue of *The Plant Press*. We hope you will enjoy reading a little about the fascinating Arizona and southwestern native floras. If you are like me, you are probably enormously disappointed that the predicted and much anticipated "El Niño of the Century" in the southwestern United States turned out to be a complete bust. Instead, the long drought conditions have continued, particularly in southern Arizona, with a corresponding negative impact on the native flora. Let's hope that the summer monsoons make up for some of the winter rain losses and that we are able to enjoy some late summer response by our native plants.

Since the New Year, the Arizona Native Plant Society has continued to sponsor and support a number of projects and activities in support of the conservation and appreciation of Arizona's native plants. A highlight of our activities this year was the annual Botany 2016 Conference which was held in conjunction with the Tri-National Sonoran Desert Symposium on 7-10 March 2016 in Ajo, Arizona. Organizations and individuals from the United States, the Tohono O'odham Nation, and Mexico were represented at the symposium. The theme of the AZNPS conference was "Plant Ecology of the Sonoran Desert: Past, Present and Future." A number of outstanding presentations were given at the conference and excellent field trips were offered to local areas of natural and historic interest.

In keeping with our decision to broaden the geographical range of our annual meetings, we are planning on holding the Botany 2017 Conference in cooperation with Prescott College on 13–14 May 2017 in Prescott, Arizona. Details are not yet finalized but will be announced as soon as they are through the AZNPS website and *Happenings* newsletter.

We have continued our various other activities in support of Arizona native plants, including monthly meetings and field trips sponsored by our six individual chapters, Citizen Science activities through Plant Atlas Project of Arizona (PAPAZ) programs, participation in native plant habitat restoration projects, and the awarding of research and publication grants by several chapters. Although not yet fully implemented, we will begin a State-sponsored research grant program later this year. Other continuing activities will include the annual three-day field trip and workshop, sponsored by the Tucson and Cochise Chapters, to be held in the Chiricahua Mountains on 13-15 August 2016.

Organizing and conducting all of these activities is no small task and I thank the individual Chapter officers and other volunteers for all their hard work in ensuring their success. I would encourage other members to come forward with their ideas for other activities we could pursue and to become more directly involved with the Society either at the chapter or state level.

As in previous issues of *The Plant Press*,we chose to highlight in this issue some of the interesting papers presented at the Botany 2016 Conference. Consequently, you will find articles on a number of botanical features of the Sonoran Desert — ranging from a discussion of the flora and ethnobotany of the Guaymas region of Sonora, Mexico, to the systematics and evolution of several iconic Sonoran Desert species (desert mistletoe and globe mallows). From a conservation perspective, one paper describes the remarkable results of a six-year AZNPS-sponsored restoration project in the Waterman Mountains while two other articles describe the commendable efforts underway by Pima County to enhance and protect native plant habitats in the Sonoran Desert.

Left *Thelypteris puberula* var. *sonorensis*. La Balandrona. Right *Stenaria sanchezii*. Los Anegados, Laura Moreno-Moreno with the holotype plant. *Photos courtesy Richard Felger.*

The Desert Edge *continued*

to Sierra Libre and Sierra Bacatete. It also includes Isla San Pedro Nolasco and islands in Guaymas Bay and near San Carlos. This is the southern edge of the Sonoran Desert, 532,000 hectares, 820 species of vascular plants. Many plants of tropical origin reach their northern limits in this region. Vegetation in riparian canyons and at higher elevations resembles tropical thornscrub and even tropical deciduous forest in wetter, shaded places, while exposed habitats support diverse desertscrub.

Above Guaymas Region. The flora area is approximately within the dashed red line, from Tastiota to the Río Yaqui and Isla San Pedro Nolasco. *Map by Alberto Búrquez.* Inset Botanist Edward Palmer, ca. 1864, Kansas City. National Anthropological Archives, Smithsonian Institution.

Once, great rivers filled the coastal plains south of Guaymas with deep alluvium. Yoemem (Yaquis) and Yoremem (Mayos) farmed these floodplains with the rich riverine waters. River deltas teemed with fish and huge sea turtles, and sometimes *caimanes* swam into the warm seawater. Today, upriver dams detain floodwaters, and what's left runs in grid-maze canals to irrigate wheat, maize, sorghum, cotton, and safflower. To the north, the Comcaac (Seri people) lived in land too arid for agriculture. Drinking water—or the lack thereof—shaped population, social structure, and movements of the people. The *Guaymas* were the southernmost Comcaac group, and in the 17th century they settled into the multi-ethnic Jesuit town of Belem (Belén) on the Río Yaqui.

Seafood fisheries, tourism, a busy harbor, industry, and the usual developments accelerated following Mexican revolutions in the early 20th century. Power plants and manufacturing smoked the sky. Traffic snarled along Calle Serdán, the main street of the port city. *Yucateco* trees (*Ficus nitida*) marched down the middle, shading the street until the mid-20th century. The people were ashamed of themselves after the trees were cut down to make way for traffic. Sailors once outnumbered tourists, but that was before NAFTA trucks and before the drug trade brought danger.

By the 21st century, 200,000 people lived in the Guaymas Region. Cattle overgraze the desert and riparian canyons. Invasive buffelgrass (zacate buffel, *Cenchrus ciliaris*), threatens ecosystems and most of the mangroves have been destroyed. Yet substantial areas look about the same as when Edward Palmer collected hundreds of specimens in the 19th century. The Sierra Bacatete likewise looks about the same as when Yoeme revolutionaries and soldiers butchered each other, the genocidal hostilities escalating into the early 20th century.

View southward to Cañón del Nacapule, with trailhead and parking lot in foreground, and San Carlos, Cerro Tetas de Cabra, and Gulf of California in background; 4 Sep 2015. *Photo courtesy of Juan Ezequiel Nuñez, © Cheque's Films Producciones, Guaymas.*

Our Guaymas Region publications will be open-access, covering 820 species, one-third of the entire Sonoran Desert flora. Among these publications will be a revised *Flora* of Cañón del Nacapule, at the heart of the region. Nacapule is one of seven canyons that contain more than 70% of the regional plant and aquatic animal species but comprise less than 5% of the total flora area of 5300 km^2. Analyses of the canyon biota by Richard and Michael emphasize the conservation values of these beautiful canyons. Alberto and Richard are completing a flora of the near-shore islands. Richard, Sue, and Jesús are co-authors of the entire flora. Scott E.K. Bennett of the U.S. Geological Survey is interpreting the geology. Richard and Felipe are completing the Yoeme (Yaqui) ethnobotany.

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Left *Agave felgeri*. Bahía San Pedro. *Photo courtesy Susan Carnahan.* Right *Brahea brandegeei*. La Balandrona. *Photo courtesy Richard Felger.*

The Desert Edge *continued*

Richard Felger's Perspective

My first trip to Guaymas was with my high school biology teacher Nancy Thomas Neeley and her husband Peter Neeley, along with UCLA ecologists from Raymond Cowles' lab. They were studying hibernating poorwills near Álamos. We camped at Bahía San Carlos. Cardón cactus branches hung over rocky ledges touching mangroves. As I climbed down into the mangroves, crabs scuttled away clicking wet sounds, and oysters and tunicates clung to tangles of stilt roots.

Three mangroves species ringed transparent seawater, one closest to the shore (black mangrove), one in deepest water (red mangrove), and one concentrated in between (white mangrove). Among fat-trunked elephant trees, purple prickly pears, and spiny bromeliads on the stony desert was a dwarf century plant—slender leaves with red margins. I prepared herbarium specimens and at a later date Howard Scott Gentry named it after me. I had a copy of Gentry's *Rio Mayo Plants*, the pages annotated with queries and discoveries.

I went to the University of Arizona because it was close to Sonora. On one of my first trips, I was camped by a lone *Sabal* palm on the cobble beach at San Carlos, undeveloped, the water sparkling. Jesús Ortega came by, and I asked about plant names and uses. He took me to Nacapule Canyon by horse. He said it was named for the *nacapule* tree at the spring and you could eat the small figs. We saw boa constrictors mating among dry, crackling fig leaves. Cattle muddied the ground below the wooden water trough. We rode into the canyon, shaded in the late afternoon of a hot summer day. Palms overtopped trees and marched up rugged rhyolite walls, and fig trees hung from cliff faces. Jesús retrieved a leather tobacco pouch and rolled cigarettes. He was proud of the gorge turning purple in the dusk.

To make the 1970 movie *Catch-22*, the directors cut down *cardones*, saguaros, and organpipes to make Algodones near San Carlos look like Italy. I met one of the directors in Tucson and gave him a talking to about desert destruction. He later fell out of an airplane while filming—he refused to wear a safety harness.

There were many fieldtrips with Ike and Jean Russell and other friends. We often camped next to Estero Soldado before construction of Condominios Pilar. Ike and Jean bought a condo to store their gear and we continued camping on the beach. Times changed and we stayed in the condo. The collections and experiences molded the foundation for my dissertation and publications.

Sue Carnahan's Perspective

My first trips to the San Carlos–Guaymas area were for sea kayaking and coastal birding; I paid scant attention to the landscape, knowing little about the desert and its ways. After a serious botany interest took hold in 2009, a hike in Nacapule Canyon prompted me to start learning and photographing the plants of the region. This led to more hikes, more photographs, a plant press, and eventually the opportunity to work with Richard and Jesús on a comprehensive flora of the region. Every visit is like a scavenger hunt, looking for new plants in old places and old plants in new places. I'm fascinated by micro-habitats: on an arid slope, a colony of cloak ferns (*Notholaena lemmonii*) survives in the shade of an organ pipe cactus. A wide-open wash turns a corner and becomes a shade-dappled canyon with thickets of *Coccoloba goldmanii* and *Zanthoxylum fagara*, patrolling gray cracker butterflies, and a wintering black-headed grosbeak. Even now after many hikes, hundreds of specimens, and thousands of photographs, I feel I've only just scratched the surface of the craggy Sierra El Aguaje and the rest of the Guaymas Region. There's so much more to find, photograph, document, enjoy.

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Left *Echinocereus llanuraensis.* Cañón La Navaja. *Photo courtesy Susan Carnahan.* Center *Ficus palmeri*. Near Cañón La Navaja. *Photo courtesy Susan Carnahan.* Right *Verbesina felgeri.* Cañón del Nacapule. *Photo courtesy Richard Felger.*

The Desert Edge *continued*

Jesús Sánchez's Perspective

Para quienes estamos maravillados por la flora y vegetación del noroeste de México, la región de Guaymas es idónea para disfrutar ecosistemas como Desierto Sonorense y Matorral Espinoso. En lo personal, tengo gran fascinación por los hábitats de arroyos, cañadas y cañones ubicados en sierras aisladas como Sierra Libre, Sierra El Aguaje y Sierra Bacatete. Mis primeras colecciones botánicas las realicé en 1999, en la Sierra El Aguaje, quedando impactado por la belleza del paisaje y su diversidad de plantas. A sitios expuestos e impactados por actividades humanas como Aguaje de Robinson y Cañón Los Anegados, le siguieron exploraciones en otros cañones más aislados como La Balandrona y Las Pirinolas.

For those of us who are intrigued by the flora and vegetation of northwest Mexico, the Guaymas Region is ideal for exploring and enjoying Sonoran Desert and thornscrub ecosystems. Personally, I am fascinated by the arroyo and canyon habitats located in isolated ranges such as the Sierra Libre, Sierra El Aguaje and Sierra Bacatete. I made my first botanical collections in 1999, in the Sierra El Aguaje, and I was impressed by the beauty of the landscape and its diversity of plants. Visits to unprotected sites impacted by human activities, such as the Aguaje de Robinson and Cañón Los Anegados, were followed by explorations of more remote canyons, such as La Balandrona and Las Pirinolas.

En 2004 visité por primera vez el Cañón del Nacapule. Contrariamente al buen estado de conservación de otros cañones de la Sierra, Nacapule mostraba signos de perturbación: basura, árboles quemados de Ficus y palmas, y la ausencia de Psilotum nudum, ya desaparecido del cañón por la sequía. Actualmente, Nacapule está administrado por particulares quienes, al parecer, tratan de conservar mejor este sitio; por ello, todavía es posible encontrar aquí muchas plantas emblemáticas de la Sierra El Aguaje.

In 2004 I visited Nacapule Canyon for the first time. In contrast to the good condition of other canyons in the Sierra El Aguaje, Nacapule showed signs of disturbance: garbage, burned Ficus and palm trees, and the absence of *Psilotum nudum*, now extirpated from the canyon due to drought. Fortunately, Nacapule is currently managed by individuals who, it appears, are trying to take better care of the site; thus, one can still find in Nacapule many of the characteristic plants of the Sierra El Aguaje.

El conocimiento adquirido sobre la flora de la Sierra El Aguaje me motivó a explorar otras localidades de la región de Guaymas. En la Sierra Libre, el Instituto Nacional de Antropología e Historia ha establecido un control de acceso al sitio arqueológico del cañón La Pintada, apoyando con ello la conservación de su diversidad vegetal que supera las 200 especies de plantas. Los registros actuales en sitios como El Tetabejo y Las Avispas, así como la obtención de registros nuevos en los sitios inexplorados, contribuirán, sin duda, a que la flora de la Sierra Libre supere las 400 especies de plantas. Un poco más al sur, se encuentra la Sierra Santa Úrsula, con una flora poco conocida, pero similar a la Sierra Libre en fisiografía y vegetación.

The knowledge I gained about the flora of the Sierra El Aguaje motivated me to explore other places in the Guaymas Region. In the Sierra Libre, the National Institute of Anthropology and History (INAH) has established controlled access to the archaeological site of La Pintada Canyon, thereby supporting the conservation of a plant diversity of more than 200 species. Recent records from sites such as El Tetabejo and Las Avispas,

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as well as new records from unexplored sites, will undoubtedly show the flora of Sierra Libre surpassing 400 species. A little farther south lies the Sierra Santa Úrsula, similar to the Sierra Libre in physiography and vegetation but with a flora that is poorly known.

Conocer la Sierra Bacatete, en el extremo oriental de la región de Guaymas, fue para mí una gran oportunidad para adentrarme en el corazón del territorio y cultura Yaqui (Yoeme), sobre todo registrando los nombres de las plantas en yoeme. En el 2008, durante la realización de un inventario preliminar de las plantas del arroyo El Álamo, en el extremo sur de la Sierra Bacatete, registramos 148 especies de plantas características del matorral espinoso de pie de monte.

Getting to know the Sierra Bacatete, at the eastern edge of the Guaymas Region, provided a great opportunity to immerse myself in the heart of Yaqui (Yoeme) territory and culture, above all by recording the Yoeme names of plants. In 2008, during a preliminary inventory of the plants of the El Álamo arroyo, at the southern end of the Sierra Bacatete, we documented 148 species of plants characteristic of foothills thornscrub.

Además del conocimiento que adquirí sobre los nombres de las plantas en la lengua, los yoemem me enseñaron el gran respeto que existe entre ellos hacia el monte, porque éste puede atrapar y desquiciar a las personas que le quieren hacer daño; así mismo, el monte atrae a las personas que elige para ser sus guardianes, les confía conocimientos y los dota de sabiduría para su propia protección. Entre los yoemem se acostumbra orar y pedir permiso al ser supremo, a los ancestros y finalmente al animal, planta, cerro o roca que será sacrificada o utilizada. Según los yoemem, la naturaleza es generosa y magnánima pero también responde en contra si es ultrajada, y esto es algo que hasta los yoris siempre deberíamos de tener en cuenta.

In addition to the knowledge of plant names in their language, the Yoeme people taught me the great respect they have for the mountain, because it can ensnare and derange people who wish to harm it. The mountain also beckons to people who choose to be its guardians, it entrusts them with knowledge and endows them with wisdom for their own protection. Among the Yoeme people, it is customary to pray and ask permission of the supreme being, the ancestors and finally to the animal, plant, mountain, or rock that will be sacrificed or used. According to the Yoeme people, nature is generous and magnanimous but she also fights back if she is mistreated, and this is something that we yoris should always bear in mind.

Coccoloba goldmanii. Cañón del Nacapule. *Photo courtesy Susan Carnahan*

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The Evolution of Desert Mistletoe Host Races: *What We Know and What Questions Remain*

by Kelsey Yule[1]

By some measures, parasites are the most successful living things on the planet. There are more parasitic species than non-parasitic ones (Poulin & Morand 2000). Evolutionary transitions to parasitism are often followed by increased speciation rates (Wiens *et al.* 2015). In fact, every multicellular species on Earth is likely afflicted with one or more parasitic species. For these reasons, in addition to concern about emerging parasitic diseases, understanding the mechanisms by which parasites gain and adapt to new host species is of great importance.

Mistletoes provide a useful system to study these processes. They comprise over 1,300 aerial-stem parasite species in the sandalwood order (Santalales) and include species that are forestry pests, critical animal food resources, and important contributors to nutrient cycling (Watson 2001; Aukema 2003; March & Watson 2010). As sessile parasites living on plants, mistletoes allow us to characterize the external and genetic characteristics of whole infections across many hosts.

My research uses desert mistletoe (*Phoradendron californicum*) to increase our understanding of the fundamental ecological and evolutionary processes related to the parasitism of multiple host species. In the Sonoran and Mojave deserts, desert mistletoe primarily infects a variety of leguminous trees and shrubs. I have focused the majority of my research on mistletoes attacking velvet mesquite (*Prosopis velutina*) and catclaw acacia (*Senegalia greggii*), as these two species are commonly found infected in the same habitats in the Tucson Basin. Although capable of performing photosynthesis, a desert mistletoe individual gains much of its sugar and all of its water and other nutrients through a parasitic connection to the xylem of its host.

The ability to effectively parasitize one host species often trades off with the ability to infect another host species. For example, mistletoes adapted to life on mesquite may not also possess the traits necessary to be able to penetrate acacia bark or deal with acacia's seasonal water stress. Therefore, when mistletoe seeds are experimentally transplanted between host species, their establishment success is reduced (Overton 1997). But how can these different adaptations be maintained when both host species are infected by the same parasite species?

The answer to this question is that the mistletoes on mesquite and acacia form different so-called "host races." Host races occur when genetically differentiated populations of a parasite infect different host species. Host races can form following a host-switching event in which a parasite colonizes a novel host species. If the races are to persist on hosts that live in the same geographic areas, some barriers to gene flow must prevent the parasites from mating and being successfully transmitted between the hosts. This differentiation allows the parasites, over evolutionary time, to adapt to life on a given host species and become specialized to interact with a certain host. Depending on how much genetic information continues to be exchanged between the host races, this process can lead to speciation,

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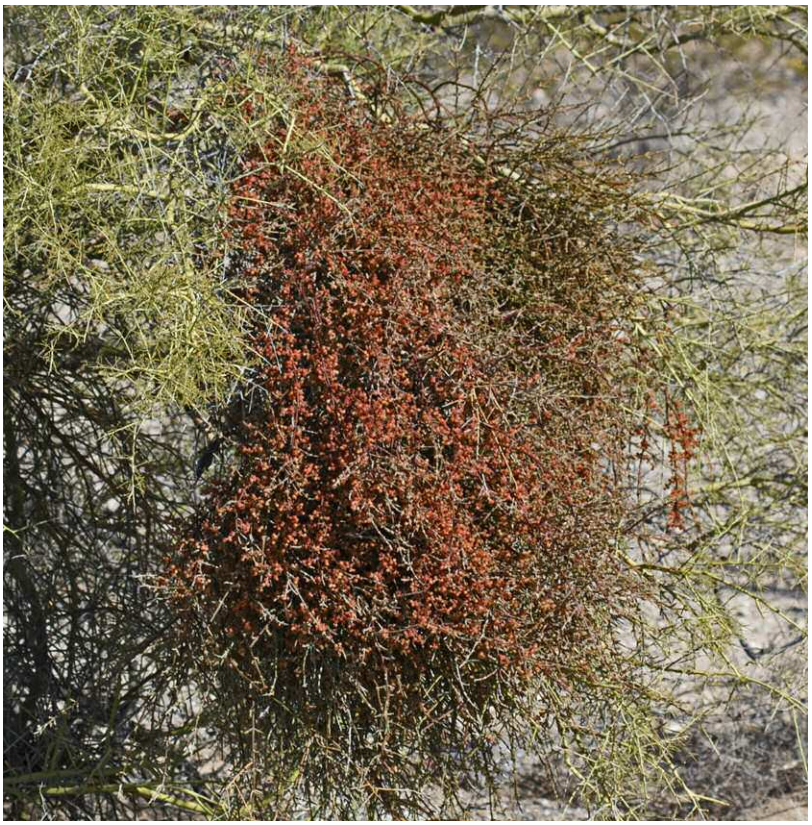

Desert Mistletoe (*Phoradendron californicum*) parasitizing Palo Verde (*Parkinsonia florida*). *Photo courtesy Arlene Ripley.*

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From left Phainopepla (*Phainopepla nitens*) male. Desert mistletoe fruit. Germinating desert mistletoe seeds.
Photos courtesy Arlene Ripley.

The Evolution of Desert Mistletoe Host Races *continued*

and is hypothesized to be a major pathway to the formation of new parasite species (De Vienne *et al.* 2013).

By characterizing the genetic structure of desert mistletoe populations on acacia and mesquite throughout Southeastern Arizona, I have found evidence for host races (Yule *et al.* 2016). The parasites on different host species tend to have different microsatellite alleles, repetitive sequences within the genome that do not code for proteins or other functions. Because these genomic regions mutate quickly but are not thought to be targets of natural selection, they give an unbiased representation of the history of populations. With these data we can understand, for example, which mistletoes are most closely related to one another and how often mistletoes from different populations interbreed. In general, I've found that mistletoe individuals tend to be more closely related to other mistletoes infecting the same host species than those on the other host species, regardless of the physical distance between the plants.

Desert mistletoe is a dioecious plant, meaning that it has separate male and female individuals. It relies on a variety of insects to transfer pollen from male flowers to female flowers in order to mate and produce fruit. Then, the seeds in those fruit must be dispersed, usually by the specialist seed-dispersing bird, the phainopepla (*Phainopepla nitens*), to a suitable host. For the genetic differentiation between mistletoes on mesquites and acacia to be maintained over evolutionary time, mistletoes must primarily mate with individuals on the same host tree species and be dispersed to a host individual of the same species.

Very few mistletoe individuals share genetic characteristics with both acacia- and mesquite-associated host races, the pattern we would expect for an individual that was the result of a mating between the two host races. What prevents the two host races from mating when they may be only a few meters apart? Differences in the timing of reproduction can be a powerful barrier to exchanging genetic material. We see this with desert mistletoe host races: mistletoes on acacia peak in their flowering about a month before those on mesquite. However, we don't yet know whether this is a direct result of the physiology of the hosts or an adaptation to reduce interbreeding.

Mating is only part of what determines the genetic structure of desert mistletoe. Dispersal and establishment of seedlings are also critical. While the timing of flowering differs between mistletoes on mesquite and acacia, both host races produce ripe fruit over the same period. Interestingly, this means that the long fruit maturation period, on average about eight months from winter to the following fall, is shorter for mesquite-associated mistletoe than for acacia-associated mistletoe. I hypothesize that the fruiting period is timed to match the activity period of phainopeplas, by far the most effective disperser of desert mistletoe in the desert habitats. Having identical fruiting time, however, means that

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The Evolution of Desert Mistletoe Host Races *continued*

many seeds are likely to be dispersed to the "wrong" host tree, as phainopeplas will be foraging for fruit on both acacias and mesquites at the same time. Indeed, about 10% of the mistletoes genetically appear to have been transplanted between host species. Given that transplant experiments have shown that moving seeds between host species reduces their chances of establishing, dispersal of seeds between hosts is probably very common.

An interesting open question is whether these transplants between the host species that do make it to adulthood are successful at reproduction. I've found that the genetic background of mistletoes correlates with their flowering time, with transplants tending to have intermediate flowering times. This pattern leads us to hypothesize that transplants may have a more difficult time finding co-flowering mates on their hosts. If the transplant mistletoes are commonly successful at mating with other plants on their host, we would expect to see more genetically intermediate individuals and, eventually, the breakdown of differentiated host races.

Careful observers of desert mistletoe will find many physical differences between those plants infecting the two host species. For example, mistletoes on mesquite tend to have larger, more densely packed flowers than those on acacia. In fact, the Seris had different words for mistletoes on different host trees and harvested berries from some but not all hosts for food (Felger & Moser 1985). Whether any of these differences are genetically determined and represent adaptations to life on a specific host remains to be seen.

Of course, desert mistletoe does not just infect catclaw acacia and velvet mesquite, but rather a wide variety of hosts, including desert ironwood (*Olneya tesota*) and palo verde (*Cercidium* spp.). Whether differentiated host races exist for mistletoes infecting any of the other host species is a topic of ongoing research. Evidence from transplant experiments and the timing of flowering, suggest that mistletoes infecting palo verdes may belong to the same host race as those infecting catclaw acacia. However, these results are only incomplete external clues to the actual evolutionary history of these parasites. If adaptation to life on palo verdes and acacias has favored similar attributes for penetration of host tissues, the transplant experiments would not be able to distinguish whether host races exist or not. Cryptic genetic differentiation between mistletoes on these host plants is certainly possible and would present a new conundrum. How do mistletoe populations associated with different host species growing together maintain genetic differentiation when they reproduce at the same time?

Another important avenue of ongoing work is the extent of host races across the range of desert mistletoe. If the host races we see in Southeastern Arizona share a common origin with host races in California, Nevada, Sonora, and Baja California, we could conclude that only one host-switching event is responsible for the current distribution of mistletoes. Alternatively, host races may have originated repeatedly in different locations throughout the range. Such work has implications for understanding how many different evolutionary trajectories a parasite can take to become adapted to a single host species.

Basic research on the genetic structure of native plants can reveal much about our natural world. Species are rarely homogenous collections of like individuals, but rather a rich assemblage of genetic diversity. For desert mistletoe, much of this diversity relates to adaptation from interactions with a host. Other plant species may show genetic differentiation related to geography or soil type. Appreciating this diversity within species can have important implications for understanding not just interactions between species, but the processes by which new species are formed and how to conserve imperiled populations.

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A Muddle of Mallows

by Ries Lindley[1]

Each year in the spring, a traveler driving along Arizona Highway 79 between Oracle and Florence will witness a riotous roadside display of common wildflowers that are largely from one genus of the mallow family. These particular mallows are the globemallows in the genus *Sphaeralcea*. It's a little hard to say where ground zero is for diversity in globemallows, but it is likely quite close to Florence. According to the *Flora of North America* there are over two dozen globemallows in the United States, and nineteen of them are found in Arizona.

These lovely plants are heartbreakers for people who want to identify plants. Although a number of species have clear, distinguishing visual characteristics, there are many plants in every species that vary so much from the "norm" that a clear-cut identification is difficult at best and impossible at times. There are plenty of good reasons for naming plants, not the least of which is that we are human, and we find it hard to think or talk about things without a name or a noun. The blurry edges of the globemallow species make us a little anxious because they push the boundaries of type and leave us casting about for words. Yet in these very quandaries there is an opportunity for a learning adventure. Why do these plants present such difficult issues for taxonomy, and in these differences is there something to be learned about the world we live in and how it works?

Although the visual characters that separate species may be obscure, there are differences in gross morphology that stand out. Visually, mallows can be pretty easily divided into two groups by leaf shape. There are those with leaves that either have no lobes or, as is more often the case, shallow lobes. The other group has more deeply lobed leaves; these appear lacy in outline. Let's take a closer look at three of the lacy-leafed plants first and then one desert species of the shallow-lobed leaf type called *S. laxa*.

Sphaeralcea coccinea is generally a small plant with usually only one flower at each node of the flower stalk and only a few flowers per stalk. *S. coccinea* also has the distinction of producing fruit that is fairly easy to distinguish from the two species that follow (Figure 1). The other two species are *S. grossulariifolia* and *S. rusbyi*. They differ more from *coccinea* than from each other in that they are taller plants, with more flowers per node and more flowers per inflorescence. These latter two are most easily distinguished from each other by the density of the hairs on the stem; *S. grossulariifolia* is hairy enough that the differences with the more sparsely hairy *S. rusbyi* can be seen with the naked eye.

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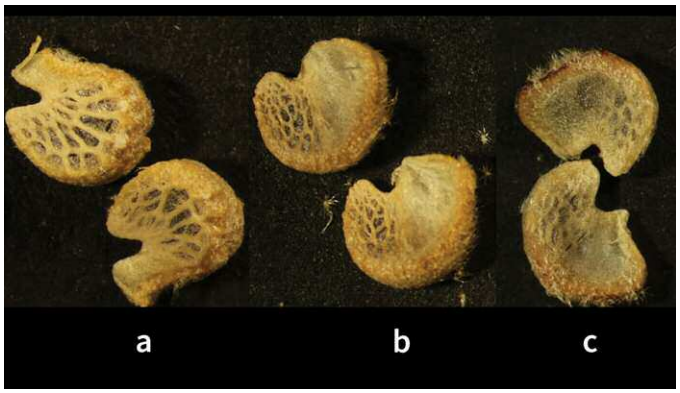

Figure 1 Carpels (segments) of mature fruit from a. *Sphaeralcea coccinea*, b. *S. grossulariifolia*, c. *S. rusbyi*. Note the netted portion of the carpel in *S. coccinea* is much greater in proportion to the other two species. Also, the netting is thicker, and the "windows" are larger. These same characters are not very helpful in distinguishing *S. grossulariifolia* and *S. rusbyi*.

If one were to walk a transect from North Dakota to Florence, Arizona, looking for globemallows, there would be nothing of this group but *S. coccinea* from Canada to the Four Corners country (Figure 2). Then in far southwestern Colorado, our walker would begin to see *S. grossulariifolia* and a little farther on, in Arizona, *S. rusbyi* would become evident. Below the Mogollon Rim, *S. rusbyi* becomes the most common of the lacy-leafed trio. As our walker entered the deserts, there would

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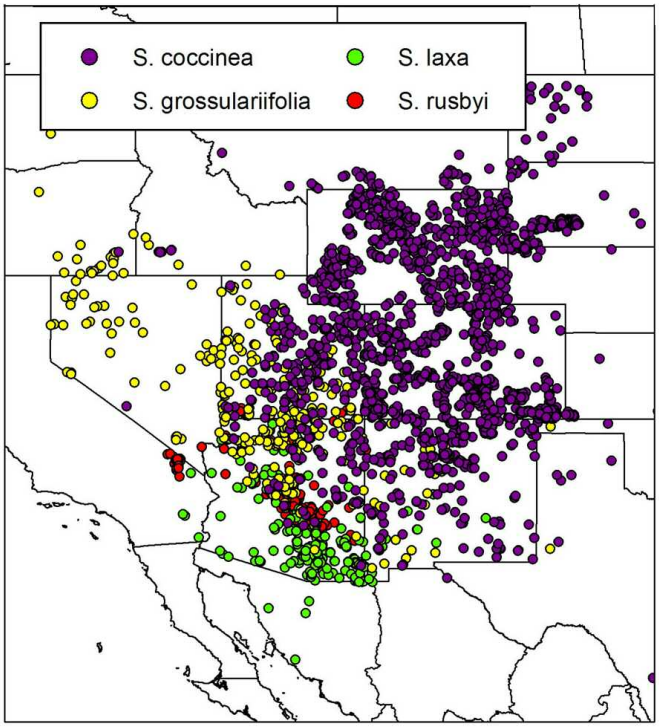

Figure 2 A view of the western U.S. including most of the range of the lacy-leafed species as well *S. laxa* in the southwest deserts. Large portions of the ranges for *S. coccinea*, *S. grossulariifolia*, and *S. laxa* do not overlap.

A Muddle of Mallows *continued*

be plants that fit their respective species descriptions well, but also a good deal with characters of more than one species, and eventually all the lacy-leafed species mentioned here would give way to the shallow-lobed leafed species, *S. laxa*.

The three lacy-leafed species considered here are similar, and in large portions of their Arizona range, they occupy the same geographic area, a condition known as sympatry. If we step back so we can view all three species ranges in the context of the whole continent, we see that *S. coccinea* occupies large swaths of the North American west, from Canada to central Arizona, and it is sympatric with *S. grossulariifolia* through western New Mexico, part of Colorado, and most of Utah as well as a large part of northern Arizona. Except for a small area in southeastern California, *S. rusbyi* shares most of its range with the other two species along an axis parallel to the Mogollon Rim in Arizona (Figure 3). This southeast-northwest trending pattern shows up in other kinds of plants too, as in shrubby dearvetch (*Acmispon rigidus*) and Utah bird's-foot trefoil (*A. utahensis*). Here again the zone of overlap in the species is parallel to the Rim, and the area of overlap is about the same as that of the lacy-leafed globemallows.

This same area of Arizona has come to the attention of a group of scientists studying Pleistocene plant refugia. Carolin Reberning, in a work based in part on Tom Van Devender's work on packrat middens, notes that areas like this served as safe harbors for desert species during the last ice age (Reberning, et al. 2010). Once the great ice sheets receded, plants radiated from here to other locations. In the case of globemallows, this area marks a boundary zone, a place from which the more xeric species repopulated the deserts, and the more mesic and cold-tolerant globemallows of the north dwindled away in those same deserts.

What does all this have to do with globemallows being so confusing? Globemallows are a little different from most other plant genera: the species hybridize freely. Dreher (2014) has demonstrated this, and he has suggested that globemallows may be more a collection of species complexes than a conventional genus. For those who tend to think of species as populations of living things that can only reliably mate like with like, this can be uncomfortable to think about.

As is common with hybrids, the first generation of offspring of hybrid globemallows tends to exhibit physical characteristics halfway between one parent and the other (Figure 4). In a wild population these hybrids will further breed with parents and parent relatives so that succeeding generations begin to approach one parent or the other in appearance. Such free hybridizing can create a taxonomic

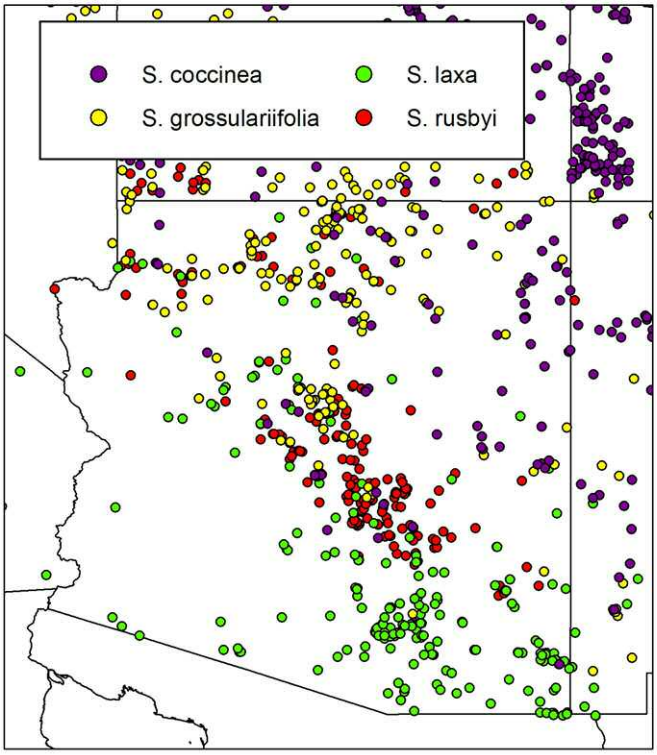

Figure 3 The distribution of all four species is shown in Arizona. The area of greatest overlap is along a zone south of the Mogollon Rim and parallel to it.

nightmare for the field botanist and is a likely scenario for what has happened to globemallows.

Thomas Kearney (1935) summed it up this way: "It would seem that the group [globemallows] is in a state of active evolution and that many of the species have not yet become sharply delimited, although they may be very distinct in their extreme forms." While this may prove a problem for plant taxonomists, it may be an opportunity for evolutionary analysis.

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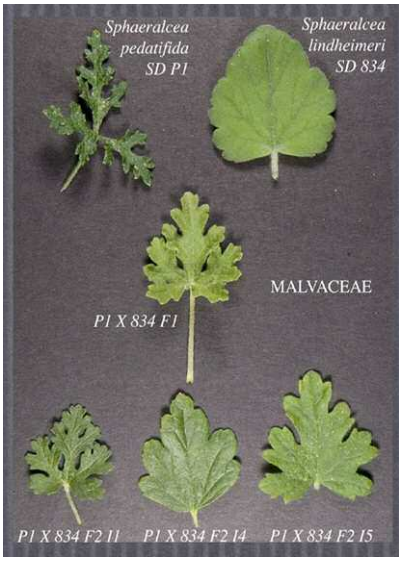


Figure 4. From Dreher's work (2014) on hybridization of globemallows. Leaves from two parent plants are shown at the top; one is lacy leafed, the other is shallow lobed. The middle plant is the first generation and exhibits intermediate characters of both parents. The bottom row shows examples of second-generation offspring, some of which approach the parents in appearance.

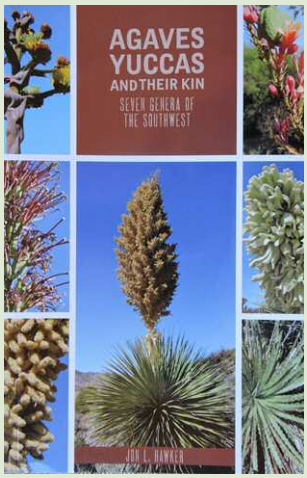
BOOK REVIEW *by Wendy C. Hodgson, Desert Botanical Garden, Phoenix, Arizona*

Agaves, Yuccas and their Kin: *Seven Genera of the Southwest*

by Jon Hawker 2016. 430 pages and 400 plus images. Texas Tech University Press. $35.23, paperback.

One fateful day a few years ago, I received a phone call from a gentleman who said he was writing a book on agaves, yuccas and their kin. This of course piqued my interest, and I listened to him describe a bit of his project, the challenges, and ask if I would be amenable to talking with him further on the subject. There was something captivating about this guy—was it his obvious passion and dedication to the project, so readily apparent in our phone conversation? His slightly off-kilter, whimsical sense of humor that even today finds me caught off guard, scratching my head, and then laughing and rolling my eyes? Whatever it was, I found myself jumping in with both feet, agreeing to meet with him in the field, looking for special agaves. Thus began a most rewarding and, I must say, oddly fun odyssey and friendship that continues to this day.

When I was asked to review his book, I wondered, "How can I provide an unbiased review for a friend on a subject of which I am deeply involved? What if it isn't good? Will I be truthful?" I agreed to write the review because, simply, I suspected it would be a great book. And, indeed, it is.



There are so many reasons this book is very good. The task of writing such a guidebook—on complex groups for which we still know relatively little but where opinions and theories are many —is no small task to say the least. Jon's purpose in writing this book is made clear at the start: "This is not really a scientific book... I am no expert in the field of plant taxonomy… I am instead in marketing, sort of an agave public relations man or a shill for yuccas, perhaps guilty of beargrass boosterism." Jon succeeded in his goal, marketing the fascinating and unique attributes of an amazing group of plants so that more people will care about them and be their advocate. What better contribution to the plant world can there be? Jon is also humble. Despite professing that he is not an expert in plant taxonomy, his writing reflects someone who not only has spent a lot of time with the plants he loves, but also someone with a deep insight and understanding of species and population dynamics and diversity as well as the complex processes in plant speciation. This is crucial to understanding and writing about the systematics of any plant group, especially plants such as these, many of which are characterized by polyploidy, hybridization, and variability — characteristics/phenomena that challenge botanists' ideas of species concepts and delimitations today. Jon's master's degree in botany and background in natural history — he is a retired professor who taught such diverse courses as animal behavior, Missouri wildflowers, and swamp ecology — contribute to his broad knowledge of plants as well as of insects and other organisms, allowing him to discuss with authority broader topics such as CAM photosynthesis and stem and leaf growth and development. While Jon states this is "not really a scientific book," he successfully weaves science — including information from peer-reviewed botanical journals and conversations with experts—with his own experiences, ideas and, of course, humor. So much information is packed into this little book that it will likely appeal to a broad audience. For example, as someone who appreciates botanical history, Jon writes how William Trelease named *Yucca harrimaneae* for Mary W. Harriman. Harriman was the wife of Edward Harriman, a wealthy and powerful railroad magnate who financed one of the biggest scientific expeditions ever, an expedition that included Trelease, John Muir, Louis Agassiz Fuertes, John Burroughs, and C. Hart Merriam. On returning from Seattle, the group's train was delayed near Helper, Utah, allowing Trelease to roam around the area, finding *Y. harrimaneae* in the field for the first time. He had only seen depauperate herbarium specimens prior to this. Upon his return to Missouri Botanical Garden, he described and named the species in Mary's honor. In 2014, Jon took me and Steve Blackwell to Helper to see the *Y. harrimaneae* population that Trelease observed and documented over a century ago. As Jon stated in his book, a fire that same year took out all of the surviving clones that had existed only a year prior. Sad, but fascinating. Historical and personal accounts such as these animate a book that will inform and entertain scientists and amateur botanists alike.

The setup of the book is straightforward, with each chapter focusing on a genus. Genera covered are *Agave, Dasylirion, Hechtia, Hesperaloe, Hesperoyucca, Nolina,* and *Yucca* of the southwestern United States. An overview of the genus is provided and includes a wealth

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Agaves, Yuccas and their Kin

continued

of information on such topics as growth habits, photosynthesis pathways, morphology and development of plant parts, ecology (soils, geomorphology, pollination ecology), ethnobotany, plant-animal relationships, seed and seedling ecology, and taxonomic history. Following the introduction to each genus is a discussion of each taxon within the genus, its description, origin of name, distribution and other interesting factoids. A map for each taxon clearly indicates general distribution as well as the extent of its territory relative to other species. Jon claims that his distribution range is "rough" and provides "approximations," but I find it adequate and informative. One can easily access SEINet for more accurate distribution data. Map data are based on several sources, including *Flora of North America*, SEINet, and various important research papers.

An especially strong feature of the book is the multitude of excellent photographs, with all but two taken by Jon. It is well known that dedicated plant aficionados/authors/botanists will go to great lengths to secure a needed photograph, herbarium specimen, or live collection. Such is the case with Jon, who routinely traveled hundreds and even thousands of miles to obtain just a bit more information or a photo, accompanied by his ever-present companion and model, Kelly, his loyal yellow lab. The photos often depict not only the requisite habit and leaf/flower/fruit close-ups, but also growth patterns, population variability, and species comparisons. And with characteristic humor, Jon describes his choice of measurements, the "Kelly Unit." You see, having photos with Kelly, his "measuring dog," as the indicator of plant size works quite well. One Kelly Unit "equals approximately 24 inches, more or less," except when "she sags a bit in the heat." Of course.

I am proud to own this excellent guidebook and am pleased to give it a fine review. Unbridled passion and dedication backed with knowledge, an openness to learning from others, and an ability to weave together all of the complicated, diverse and fascinating ideas and facts of these iconic plant groups make this a unique, must-have book. And did I mention his sense of humor? Upon reading an insert at the very beginning, one gets the sense that this book is not going to be like any other guidebook: "Outside of a dog, a book is a man's best friend. Inside of a dog it's too dark to read. Groucho Marx." Thank you, Jon.

A Muddle of Mallows

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Lyman Benson of Pomona College spent a portion of his career studying hybrid oak swarms in California, while Verne and Karen Grant spent time studying hybrids in cacti. The downside of oaks and cacti as study subjects is that they are slow to reach breeding age. To understand trends in hybrids it is important to be able to do controlled growth experiments with them, and plants that are slow to mature sexually are an inhibition to human botanists whose own short life cycle demands a more immediate gratification. Arizona globemallows on the other hand are also perennials but often flower in the first year. Other than experiments done with single-celled entities, that is about as good as it gets for quick breeding studies.

To return to the question posed above, why are these plants difficult and is there something to be learned from them, here are some answers. They are probably difficult because they hybridize freely, and the species broadly overlap in Arizona. The answer to the latter question is most certainly yes. Globemallows provide an opportunity to study a number of things. Why is the area south of the Mogollon Rim a center for species diversity? Are these plants radiating from a Pleistocene refugium, and if so, how? Are the globemallows in the process of evolving new species as Kearney has suggested? Or is it possible in a world of both natural and man-made climate change that the very broad diversity created by hybridization is not a path to birthing new species but is more importantly a primary strategy for survival?

For the naturalist, the true bounty of nature is its endless opportunity for learning, and in our efforts to understand nature, we come to a better appreciation of her beauty. Next spring, sometime in mid-March, take a drive along the less-travelled highways of Arizona. Make the endpoints of the drive Superior and Oracle and make sure you pass through Florence on the way. Enjoy the globemallows, and don't worry too much about what they are called. The globmallows don't know either and by whatever name would smell as sweet.

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Comparison photos of restoration results from one of five photo-points: 2010 (left) and 2013 (right). *Photos courtesy James Cowlin.*

The AZNPS-Led Waterman Restoration Project: *Helping the Sonoran Upland Desert to Heal Itself*

by John Scheuring[1]

The Setting

The Waterman Mountains are a rare limestone desert uplift 30 miles northwest of Central Tucson within the confines of the Ironwood Forest National Monument (IFNM) and administered by the Bureau of Land Management (BLM). The Watermans are home to several alkali-loving plants, including the federally listed endangered species the Nichol's Turk's head cactus (*Echinocactus horizonthalonius* var. *nicholii*), elephant tree (*Bursera microphylla*), ocotillo (*Fouquieria splendens*) and desert agave (*Agave deserti*). The Waterman bajadas are dominated by saguaros (*Carnegiea gigantea*), foothill palo verdes (*Parkinsonia microphylla*), and ironwood trees (*Olnea tesota*), with an understory of diverse grasses, forbs, and cacti. Desert bighorn sheep (*Ovis canadensis* ssp. *nelsoni*), desert tortoise (*Gopherus morafkai*), as well as many species of desert birds thrive in the Watermans.

Land Disturbance and Invasive Introduction

In March 1981, Harlow Jones, a mining entrepreneur and small aircraft salesman, illegally bulldozed 18 acres of undisturbed desert bajada on the northwest side of the Watermans. The disturbance included a one-kilometer airstrip. Mr. Jones lived onsite with his family from 1982 until 1997 when he was declared a trespasser by BLM and forced to leave. BLM requested that Mr. Jones plant vegetation on the disturbed land. Mr. Jones responded by planting buffelgrass (*Pennisetum ciliare*). By 2005, the entire 18 acres as well as 10 acres of peripheral desert were heavily infested with buffelgrass.

Initial Attempts To Control Buffelgrass

There were recurrent efforts to control the buffelgrass: Sierra Club volunteers manually removed plants (2005-2009) and BLM contracted for annual herbicide sprayings (2008-2009). But the soil remained charged with seed, and there was regrowth whenever there was sufficient rainfall and warm weather (Feb-March and July-October).

In June 2010, the Tucson BLM field office organized heavy-equipment to reshape and contour the entire site. In July 2010, the Arizona Native Plant Society (AZNPS) began a volunteer restoration effort and the recovery of the site began in earnest.

Tree Seeding

In the summer of 2010 AZNPS volunteers harvested palo verde and ironwood pods, along with whitethorn acacia (*Vachellia constricta*) seeds. In August and September of 2010, volunteers planted the pods and seeds directly without any chemical treatment or seed scarification. By mid-September well over 2,000 tree seedlings emerged. During the following six years, there has been an ongoing effort to plant seeds in gaps where trees have not emerged. In addition to the tree species, volunteers have harvested and planted seed of ocotillo, prickly pear (*Opuntia engelmanii*), and triangleleaf bursage (*Ambrosia deltoidea*). BLM has

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AZNPS-Led Waterman Restoration Project *continued*

Same photo-point in 2015. *Photo courtesy James Cowlin.*

given AZNPS permission to annually harvest saguaro seed and broadcast those into the dripline of growing palo verde and ironwood trees. No irrigation or supplemental water has been brought to any plants on the restoration site since the beginning of the project. By 2016, some of the trees seeded in 2010 exceed 6 feet in height and are bearing seed. A tree inventory made in May 2016 resulted in a count of over 2,500 trees. Tree seedlings are culled where their density is greater than trees in adjacent desert.

Bringing Buffelgrass Under Control

BLM provided backpack sprayers and glyphosate herbicide to AZNPS for buffelgrass control on IFNM. By mid-August 2010, after the site had been contoured with heavy equipment, the entire restoration site had sprouted in buffelgrass seedlings. AZNPS-led volunteers spot sprayed young buffelgrass plants three times weekly from August through October. No buffelgrass plants were allowed to flower. Volunteers were trained to identify look-alike native grasses so they could carefully direct spraying only at buffelgrass plants. Buffelgrass spraying continued every year with a sharp drop-off of buffelgrass plants emerging each year. Total herbicide applied in 2010 was 234 gallons and by 2014 the total applied was only 3 gallons for the same area. By 2016 only a few plants are still found and have been easy to identify and pull out manually.

Fixing Problem Areas

Four major problem areas covering two out of the total 18 acres were identified with little or no plant growth. Soil analyses were conducted on the recommendation of a UA soil scientist. The conclusion was that there was no soil toxicity problem but rather a soil moisture-holding limitation. This limitation could be corrected with the construction of bermed terraces and one-rock dams to capture and retain runoff water. During a five-year period, over 150 structures were built with over 2,000 hours of volunteer manpower. There was a dramatic plant establishment and growth response to the enhanced moisture in and adjacent to the bermed terraces and one-rock dams. Volunteers made sure that runoff water would spread and soak in rather than pool in one area. In areas where water was allowed to pool, there was poor plant emergence and growth. There were large upland bare ground patches across the site where no plants emerged.

According to an infrared thermometer, mid-June, afternoon soil temperatures averaged 145F°. Bare areas overlayed with tree and brush cuttings averaged 115F°. Based on that difference, and also the fact that shaded soil dries out more slowly than soil in the full sun after rainfall, project leaders decided to amend the bare soil with tree and brush cuttings. Over a five year period approximately 300 pickup truck loads of tree branches were hauled onto bare areas with a marked increase in plant establishment within 24 months.

Native Species and Vegetative Coverage

Plant species on the site were routinely noted. Vegetative coverage, other than the planted tree seeds, resulted from seed coming from adjacent desert areas. Currently, 102 native species have been identified. This list includes 20 native grass species and two spontaneously occurring Nichols Turk's head cactus discovered in April 2016. At the outset of the project in 2010, seven 50-meter transects were established. Vegetative coverage and species counts are made each year in mid-October. By 2016 the vegetative coverage had plateaued at 61%, with little change in the overall coverage from year to year as numerous small grasses were replaced by larger and fewer perennial plants. Five photo-points were established and sets of repeat photographs have been taken annually in mid-October.

Plant Establishment and Succession

A few species were noteworthy in their rapidity and extent of early establishment: woody crinklemat (*Tiquilia canescens*), brittlebush (*Encelia farinosa*), purple and six-weeks threeawn grass (*Aristida purpurea* and *A. adscencionis*), fluffgrass (*Dasyochloa pulchella*), and globemallow (*Sphaeralcea ambigua*). In Spring 2016 two Nichol's Turks head cacti had established in the runway area of the site. All of the native plant species seed was either *in situ* or blown in from the adjacent desert.

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Comparison photos of restoration results from a second photo-point: 2010 (left) and 2013 (right). *Photos courtesy James Cowlin.*

AZNPS-Led Waterman Restoration Project *continued*

Two species were notable for their contribution of copious amounts of plant litter to the bare soil: fluffgrass and trailing four-o'clock (*Allionia incarnata*). Both of those species germinated and grew all year long whenever there was sufficient moisture available. Both species regularly died off and provided litter and ground cover, allowing for germination of successional species such as hoary abutilon (*Abutilon incanum*) and triangleleaf bursage (*Ambrosia deltoidea*). By 2016, there was an obvious succession of brittlebush yielding to triangleleaf bursage. This succession was expected as triangleleaf bursage is a dominant shrub and brittlebush is rare in adjacent undisturbed deserts.

Fauna Establishment

In 2010 and 2011, only two vertebrate animal species were regularly seen, rock wrens and coachwhip snakes. By 2014, black-throated sparrows were already nesting in prickly pear and young palo verde trees. A few blacktail rattlesnakes were found and whiptail lizards appeared throughout the site. The first Harris' antelope squirrels were sighted. By 2016, there were extensive rodent holes and ant colonies. Desert bighorn sheep regularly began grazing on the site.

Discussion and Conclusions

Within a six-year period, a near monoculture of buffelgrass was eliminated and an Upland Sonoran plant community was well on its way to re-establishment. Repeated and careful spot-spraying of the buffelgrass made room and available moisture to native plants without further ground disturbance. By the fourth year, herbicide application was negligible. Woody-tree species planting from seedpods proved to be very effective. While there was never any hand-watering or artificial irrigation, the trees and shrubs have benefited from the extensive water harvesting effort that resulted in keeping most of the rainfall and incoming runoff on the site itself. No seed mixes were planted. All of the species now growing on the disturbed area share the same genetics (not just species commonality) as native plants in adjacent deserts.

Bulldozing and scraping of the soil by Mr. Jones resulted in a depletion of organic matter and soil surface litter. The soil disturbance also resulted in poor water permeability. The accumulation of plant litter, especially from native grasses has resulted in gradually growing plant associations and

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Second photo-point in 2015. *Photo courtesy James Cowlin.*

AZNPS-Led Waterman Restoration Project *continued*

enhanced water penetration. The extensive amendment of tree brush as well as an amendment of significant litter from the woody degradation has enhanced plant growth. It took six years before widespread rodent, lizard, and ant holes appeared. Those holes will continue to enhance water penetration and retention in future years. Newly established palo verde trees started bearing seedpods in 2015 and that seed pod and tree litter production will increase in multiples over future years, providing habitat for nurse plants and fauna.

This effort has spanned six years and included approximately 5,000 dedicated volunteer hours. Had the effort followed the typical 2- or 3-year project lifecycle without sustained continued effort, the land would have reverted to buffelgrass, and erosion channeling would have left most of the area dry and barren. Year after year, buffelgrass seedlings were removed, erosion channels were rocked as they appeared, berm terraces were repaired and reinforced, and bare areas were covered with brush and replanted with tree seed.

This project demonstrates that timely interventions can indeed reclaim the desert from buffelgrass invasions and other disturbances and put in place the essential ingredients for desert regeneration. But focused attention, hard work, and multiple years are required.

Acknowledgments

I thank colleagues from the Arizona Native Plant Society for guidance, consensus agreement, and support. Exceptional contributions were made by Ries Lindley for floristic expertise, Dennis LeBlond for his leadership in the water harvesting effort, and Chuck LeFevre for his assistance in harvesting and conditioning native seed. I thank the BLM Tucson Field office for administrative and tool support. Several UA professors, especially Dr. Jim Walworth, provided technical guidance. Dr. Emilio Carrillo from the Natural Resources Conservation Service provided technical advice. Mr. Harlow Jones' personal interview was informative. Finally, thanks are due for the volunteer support from the Arizona Native Plant Society, Sierra Club Arizona, the Dove Mountain Hikers, the UA SWES Student Club, Catalina Council, Boy Scouts of America, the Desert Museum Youth Earth Club, and numerous BLM Tucson Field Office interns.

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The Kino Ecosystem Restoration Project near Tucson Boulevard and Ajo Way may be southern Arizona's largest stormwater harvesting facility. Runoff sustains wetland and native riparian vegetation but is also piped outside the basin for use on the Kino Sports Park and roadway medians. *Credit: Brian Powell, Pima County.*

Pima County's Native Plant Program *by Julia Fonseca*[1]

Beginning in 2001, Pima County looked to native plants to minimize some of the more harmful impacts of urban development on native plant communities and the organisms that depend on them. The achievements of the past 15 years have been documented in a recent report, entitled "Improving Native Plant Salvage and Re-establishment" available at **www.pima.gov**. The report highlights several areas where continued efforts for improvement may provide substantial benefits, including water harvesting and irrigation techniques, integration of plants with other low-impact development practices, native seed and plant availability, use of groundcover treatments, early identification of invasive, non-native landscaping plants, and public education.

The range of expectations that is served by native plants has broadened over the years. The original Native Plant Program was primarily focused on the use of native plants as a valuable resource to wildlife. A 1996 University of Arizona study found that only 10% of the plants used in suburban landscapes were native. Today Pima County is relying on native plants for a wider array of purposes, including the capture of pollutants in runoff and to reduce long-term maintenance costs of landscaping in public rights-of-way.

The Native Plant Program started as an outgrowth of a regional effort to balance economic growth with the protection of natural and cultural resources, known as the Sonoran Desert Conservation Plan. New road design standards, floodplain management, land acquisition, ranch conservation and management, identification and management of invasive, non-native plants, rehabilitation of damaged lands, and public education are all components of this effort. The County's native plant nursery, established in 2003, has greatly reduced the impact of County projects on native vegetation and has provided a myriad of educational opportunities to Pima County citizens (see article, p. 20).

The Pima County Regional Flood Control District brings another important dimension to the Native Plant Program through active efforts to rehabilitate floodplains that have suffered damage from previous land uses. One example lies at the end of Columbus Boulevard, where a gravel pit and former pasture have been restored to a native plant community supporting various wildlife species along the Rillito segment of the The Loop. The Kino Ecosystem Restoration Project, located next to Sam Lena Park, transformed a muddy detention basin into wetlands and cottonwood-willow forests that are sustained by stormwater harvested from Tucson's urban areas.

The Flood Control District's floodplain management ordinance has also played a key role in protecting vegetation along streambanks. This ordinance applies to construction projects in unincorporated Pima County that require a floodplain permit, and requires that the permittee make efforts to avoid impacts to vegetation along watercourses. Where it is not feasible to avoid or minimize the impact, the owner may be required to plant native vegetation upon project completion. This ordinance is a critical measure aimed at preserving the riparian plant communities that slow the flow along watercourses, provide important wildlife habitat, and improve stormwater quality.

The highest profile aspect of the Native Plant Program has been the acquisition of natural areas following voter approval of 1997 and 2004 open space bonds. With these funds, Pima County has protected such treasured places as Tumamoc Hill, Canoa Ranch, Sweetwater Preserve, Painted Hills, the A7 Ranch near Redington, and the Sands Ranch

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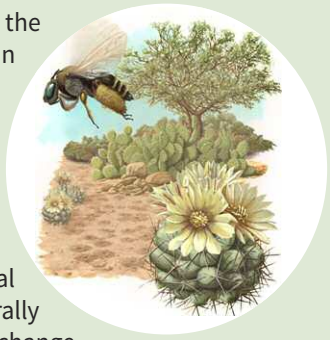
What is the Section 10 permit?

On May 13, 2016, the U. S. Fish and Wildlife Service (Service) indicated that they were prepared to grant a "Section 10" permit to Pima County. This approval is formal recognition of the benefits provided to federally listed species from the various conservation measures our community has taken under the Sonoran Desert Conservation Plan, most importantly the acquisition and management of working ranches and County parks, many of which were acquired with voter-authorized bonds. Those County-owned lands used for mitigation under the permit will be legally protected against future development in perpetuity.

The Section 10 permit formalizes a set of commitments and benefits to the County and its regulated development community that have been implemented over the past 18 years, including certain provisions of the Floodplain Management ordinance that help to protect riparian habitat. By adhering to these commitments, the permit will provide regulatory certainty for a recovering economy by ensuring that no additional commitments will be needed over the term of the permit. The permit will streamline compliance with the federal Endangered Species Act (ESA) for public and private projects affecting nine species currently listed under the ESA, and ensure that if any of the 35 additional species that are also covered under this permit become federally listed during the permit's 30-year duration, the rules will not change.



In return for this certainty, Pima County is responsible for protecting, managing, and monitoring the County-controlled mitigation lands. Annual reports will be made available to the Service and the public regarding the condition of the mitigation lands and the status of its species, as well as documenting development under the permit.

The permit will not go into effect unless an Implementing Agreement is signed by the Pima County Board of Supervisors later this year. Find out more at www.pima.gov/mscp.

Inset The Pima Pineapple Cactus is a federally listed endangered species covered by the Section 10 permit. Pima County is working with the University of Arizona and U. S. Fish and Wildlife Service to test a new monitoring strategy (distance sampling) as a means of accurately estimating population sizes for this hard-to-find species. The cactus is thought to be pollinated by a solitary, native ground-nesting bee, *Diadasia rinconis*. Because Pima Pineapple Cactus only blooms for a brief part of the year, this bee species relies on other species of native cacti that flower during other times of the year, so conservation and salvage of more common prickly pear cacti, cholla, and barrel cacti contribute indirectly to the persistence of the Pineapple Cactus by supporting its primary pollinator. *Illustration by Bill Singleton, Pima County.*

Pima County's Native Plant Program *continued*

near Sonoita from development. These lands possess outstanding examples of large tracts of Sonoran Desert vegetation, as well as semi-desert grassland. The open space acquisitions have inspired additional land donations for the public good, from owners who have similar aspirations for long-term protection of beautiful natural landscapes.

If approved by the Pima County Board of Supervisors, Pima County will soon embark upon a rigorous monitoring program aimed at the conservation and management of the plant communities and other habitat conditions on these open space lands, as part of the Section 10 permit. This will provide another layer of accountability to citizens that the acquired lands are being protected and managed over the long term. Vegetation plots will be established and monitored on County-managed lands for 30 years using methods developed by the National Park Service's successful Inventory and Monitoring Program.

In conclusion, Pima County has made remarkable progress in implementing the recommended actions originally identified by staff in 2001. This has resulted in a development approach that emphasizes the preservation of native plants and soils, the successful salvage of native plants where necessary, or the post-construction land rehabilitation with comparable native plants where the disturbing of natural areas is unavoidable. In other more urban sites, native plants grown in the County nursery are being used for landscaping of public works projects, restoring of wildlife habitat, providing beauty, attracting pollinators, and reducing water use.

At every turn, more uses for our tough and stunning native plants are being found: most recently in addressing stormwater pollution, drought, reducing landscape maintenance costs, and ameliorating urban heat island effects. While many of these uses and benefits were not explicitly addressed in the original native plant report, they nonetheless serve to validate the County's successful development of a native plant program.

SPOTLIGHT ON A NATIVE PLANT *by Ronald A. Coleman, Tucson, Arizona, ronorchid@cox.net*

A New Orchid for Arizona and the U.S. (*Hexalectris parviflora*)

This note on the discovery of a new orchid for Arizona and the United States, *Hexalectris parviflora* L.O. Williams, is based on a recently published article (Coleman and Fox 2015).

Janet Fox, of WestLand Resources, Inc., has been conducting surveys for *Hexalectris* species, specifically *H. arizonica* and *H. colemanii,* in southeastern Arizona since 2010. In early May 2015, Fox observed an orchid in the Dragoon Mountains in Cochise County that she did not recognize as any of the three *Hexalectris* species then known to occur in southeastern Arizona. There were three patches of the unknown orchid totaling just over 30 plants. A few weeks later, one more of the plants was observed by Teague Embrey of WestLand Resources Inc., in the Peloncillo Mountains of southeastern Cochise County.

WestLand Resources, Inc., contacted Ronald Coleman and requested help identifying the unknown orchid. Coleman is familiar with the other *Hexalectris* in the United States, having studied and photographed all of them in habitat, and was a contributing author to the treatment of *Hexalectris* in the *Flora of North America* (Goldman et al. 2002). Coleman visited the site in the Dragoon Mountains and immediately recognized this was a *Hexalectris* species new to the United States.

Coleman reviewed the Kew World Checklist of Selected Plant Families (WCSP 2015) which suggested the newly discovered plant would be either *H. brevicaulis* or *H. parviflora,* and then he examined the specimens of *H. parviflora* at the University of Arizona Herbarium. Details of the pressed specimens matched the orchids that Fox, Embry, and Coleman had observed in the field. Based on the original species description (Williams 1940), and examination of the herbarium material, Coleman determined the unknown orchid was *Hexalectris parviflora*. This is the first record of *H. parviflora* in Arizona and the United States.

The flowers of the *H. parviflora* observed in the Dragoon and Peloncillo Mountains were dark purplish-red with the central lobe of the lip and lamellate calli bright magenta with white side lobes. Natural spread of the flowers ranged from 1.3 cm to 2 cm across the lateral sepals.

L.O. Williams (1940) described *H. parviflora* based on plants from Sonora, Mexico, and described the range extending to Guatemala. Kennedy and Watson (2010) provided greater definition of the range of *H. parviflora* showing it extending along the Sierra Madre Occidental into northern Mexico. The discoveries in the Dragoon and Peloncillo Mountain Ranges in Southeastern Arizona represent northern range extensions of 264 miles and 224 miles respectively.

The *H. parviflora* were found in mixed oak/pine woodland of about 50% canopy cover. Two other members of the genus *Hexalectris* were growing in the Dragoon Mountains habitat. *Hexalectris colemanii* was just coming into bloom, some within 2 meters of the *H. parviflora*, while *H. arizonica* was in early spike about 100 meters away. This is the only location in Arizona where three *Hexalectris* species are known to occur together.

A voucher specimen is deposited at the University of Arizona Herbarium as collection specimen number AZ 422980. Janet Fox collected a photographic voucher of the plant in the Dragoon Mountains, which is stored in the Southwest Environmental Information Network (SEINet 2015) as General Observation Janet Fox 006. Teague Embrey collected a photographic voucher of the plant in the Peloncillo Mountains, which is stored in SEINet as General Observation Teague Embrey 190 (SEINet 2015).

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Photo courtesy Ron Coleman.

Pima County's Native Plant Nursery: *Preserving and Promoting Urban-Area Biodiversity*

by Jessie Byrd[1]

In 2001, as part of the Sonoran Desert Conservation Plan, Pima County staff wrote and prepared a proposal for a Native Plant Program that would minimize some of the more harmful impacts of urban development on native plants and plant communities and address some of the problems that public works departments had found in obtaining appropriate plant material for projects. Since then, Pima County has put many of these ideas into practice, including creation of the Native Plant Nursery. The nursery is an important component of the Sonoran Desert Conservation Plan, which besides preserving open space and habitat for endangered species, also requires conservation and replenishment of the natural environment within the urban metropolitan area. Over the past fifteen years, the Native Plant Nursery has provided tens of thousands of Sonoran Desert native plants for landscaping County public works projects, including outside buildings, in parks and along roadways. Pima County's Native Plant Nursery is leading the stewardship effort to reintroduce native plants into our "urban desert," putting the desert back where it belongs.

The Native Plant Nursery is located on two acres at the Pima County Natural Resources, Parks and Recreation main facility at 3500 W. River Road, Tucson. At present, there are over 20,000 plants being grown for a variety of public projects, representing over 200 different species. The water source for the Native Plant Nursery is a high-nitrogen groundwater source that is not suitable for potable purposes but excellent for plant propagation.

The Native Plant Nursery maintains a native seed library of 130 species. Most of the seeds are collected from Pima County natural areas, ideally as close to the specific project locality as possible. Growing plants from seed increases their resiliency by preserving the diversity within that species. Screwbean mesquite (*Prosopis pubescens*), creosote bush (*Larrea tridentata*), and whiplash pappusgrass (*Pappophorum vaginatum*) are easy to grow from seed and perform well in the nursery setting. Some plants are produced from cuttings when the seeds are challenging to collect or germinate. Fremont's Cottonwood (*Populus fremontii*) and arrowweed (*Pluchea sericea*) are produced from cuttings.

All of the plants grown by the Native Plant Nursery end up in public spaces. Participating departments have included Transportation, Flood Control, Water Reclamation, Development Services, Sustainability and Conservation, Natural Resources Parks and Recreation, Community Development and Neighborhood Conservation, Pima County Public Libraries, and several public schools. Plants

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Tubers of salvaged Queen of the Night cactus. *Photo courtesy Pima County Communications.*

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Palo verde seedlings. *Photo courtesy Jessie Byrd.*

Pima County's Native Plant Nursery

continued

are grown out specifically for projects and the nursery can care for them during months-long construction windows.

In addition to growing plants from seed, Pima County's Native Plant Nursery salvages plants that would otherwise be destroyed by County construction projects. The nursery holds a state-agency permit from the Arizona Department of Agriculture which allows nursery staff to relocate protected cactus and succulents from Pima County properties that are being developed and move them to the Native Plant Nursery without an individual transport tag. Thousands of mature, native plants have been saved from the landfill by the nursery staff and these plants become available nursery inventory. In this manner, existing Sonoran Desert species diversity is preserved and these plants can find a new home where they can continue to act as habitat or provide pollinator resources, among many other ecosystem functions. Over 4,000 Graham's nipple cactus (*Mammillaria grahamii*) have been plucked from the desert and are in holding at the Native Plant Nursery, where these plants continue to flower profusely.

One of the most special plants salvaged by the Native Plant Nursery staff is *Peniocereus greggii,* the Arizona Queen of the Night. Over 100 of

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Nursery visitors enjoying the Queen of the Night cactus (*Peniocereus greggii*) in bloom. *Photo courtesy Pima County Communications.*

Jessie Byrd at Pima County's Native Plant Nursery. *Photo courtesy Pima County Communications.*

Pima County's Native Plant Nursery *continued*

these Sonoran Desert beauties have been rescued. These treasured plants find new homes in public landscapes where they are accessible to the public, in places like Pima Prickly Park and the Martha Cooper Library. Most of the collection is held at the Native Plant Nursery for a free viewing event on bloom night and the following morning. Every year, the public is invited to see and appreciate these plants that belong to them.

The nursery does not sell or make plants available to the general public, but the public benefits. Having green space in an urban area leads to a healthier population. By putting these plants back into our urban areas the pollinators are receiving the resources that they need. So not only are we doing something that we know is good for the people in an urban area, we're also doing something that is really good for the critters in an urban area. And that way the entire ecosystem, everyone who is living in the desert, is benefiting from these plants.

The Native Plant Nursery is open for tours and welcomes volunteers interested in growing and maintaining Sonoran Desert native plants for the community. Contact Jessie Byrd at **jessie.byrd@pima.gov** or (520) 488-8022 for more information.

Cortaro Farms Road saguaro cactus salvage. *Photo courtesy Pima County Communications.*

Salvaged Graham's nipple cactus (*Mammillaria grahamii*). *Photo courtesy Pima County Communications.*

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For more information, please write to AZNPS (see return address above), visit **www.aznativeplantsociety.org**, or contact one of the people below:

Cochise: Doug Ripley, jdougripley@gmail.com

Flagstaff: Dorothy Lamm, 928.779.7296

Phoenix: Michael Plagens, 602.459.5224

Prescott: Sue Smith, 408.507.7706

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