The Plant Press

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The Arizona Native Plant Society

In this Issue:

Interdisciplinary Botany

& Our Regular Features

Wild sunflower, Rio Rico, Arizona, 23 August 2014. *Photo by Susan D. Carnahan.*

Arizona Native Food Plants for a Dry Future

by Richard Felger[1]

While learning some of the intricacies of Western Apache knowledge of food plants and historic landscapes, I wondered: How different would it be if they or other Native Americans had been able to teach invasive Euro-Americans about native food resources and greater respect for local ecosystems?

The Sonoran Desert Region is rich in plant diversity, and rich in plants used for indigenous cuisine. Dozens of such wild plants are suitable for agricultural crops and home gardens. Fit the crop to the land, not the land to the crop: the concept includes no-tillage land use and native plants that have been wild-harvested since ancient times. The implications for energy and water conservation are huge.

Some years ago I had the privilege of searching the world for new aridland/salt-tolerant food crops and now I find some of the best ones right here in our backyard. Among the

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

As 2014 comes to a close I wish to thank all members for their fine support of the AZNPS during the past year. I think we can look back on the year with satisfaction for the many significant AZNPS accomplishments to which many of you contributed. I am also very grateful to our Board of Directors, members of which have consistently provided support, encouragement, and new ideas for the successful management of the Society.

During the past year we continued to sponsor a wide range of activities and programs in support of native plant awareness and conservation. Habitat restoration projects, Citizen Science programs in support of the Plant Atlas Project of Arizona (PAPAZ), plant family taxonomy workshops held in cooperation with the University of Arizona Herbarium, financial support for native plant research and publications through various chapter grant programs, and our annual Arizona Botany Conference are a few of the more significant endeavors accomplished this past year. We definitely plan on continuing, and possibly expanding, these activities in 2015. I am particularly impressed with the potential to expand our Citizen Science efforts by engaging more of our members, expanding our cooperation with local universities, and possibly partnering directly with Arizona's Natural Heritage Program and NatureServe, the non-profit conservation organization whose mission is to provide the scientific basis for effective conservation action. NatureServe and its network of natural heritage programs and conservation data centers are the leading source for information about rare and endangered species and threatened ecosystems and are actively seeking to partner with native plant societies to support their Citizen Science efforts.

In 2015 we will hold the Arizona Botany Meeting in cooperation with the Museum of Northern Arizona, Flagstaff. Please mark your calendar for 26-27 April 2015. Full details regarding the theme and a call for papers will be forthcoming soon.

Although we have many worthwhile projects and activities planned for 2015, we could certainly do more. I therefore ask that you consider expanding your participation in the Society and to let us know of new efforts the Society could initiate or support.

The Plant Press continues to serve as our semiannual journal for the dissemination of information on Arizona's native flora. As such it offers an excellent forum for individuals to publish the results of their botanical research or other experiences with native plants. I ask all members to please consider submitting native plant related information, results of research, or any other items of botanical interest for inclusion in future issues.

This issue of *The Plant Press* contains selected papers based on presentations at the 2014 Arizona Botany Meeting, the theme for which was "Interdisciplinary Botany: How Related Scientific Fields Support Our Understanding of Native Plants." Consequently these papers reflect a diversity of subjects, ranging from a discussion of the potential to develop new native food plants; the results of an investigation of the evolutionary genetic processes of hybridization and polyploidization among species of the primitive vascular plant genus *Selaginella* in the Sonoran Desert; and, a description of soils and their role in plant evolution, distribution and regional diversity from the Upper Verde River, Arizona. Finally, we present a report of an April 2014 Madrean Archipelago Biodiversity Assessment (MABA) Expedition to the Sierra Huérfana, Sonora, Mexico, that resulted in over 1,000 biological observations which helped provide documentation of the unique biodiversity of that important Sky Island.

  

Opposite: Wild sunflower, Rio Rico, Arizona, 23 August 2014. *Photo by Susan D. Carnahan.* Above, left: Eric Leahy harvesting wild sunflowers near the Gila River in New Mexico, with a sheet over the hood of the pickup, 15 October 2014. Center: Initial screening of sunflower achenes ("seeds") by Eric Leahy and Gregg Dugan, 15 October 2014. Right: Winnowing freshly screened sunflower achenes, 14 October 2014.

Arizona Native Food Plants for a Dry Future *continued*

several hundred wild food plant species in the Sonoran Desert Region, several dozen provided Native Americans with staples. Wild regional staples include agaves, saguaro and organ pipe, mesquites, sunflowers, a richness of grasses, even native palms, and many more. Some of these wild food plants are promising "new" food crops for home gardens as well as large- and small-scale agriculture. Certain South American mesquites, or *algarrobas*, are gaining major significance in their native lands, and our native mesquites are likewise gaining prominence as local food resources.

Driving from Tucson to New Mexico in late summer I noticed the native sunflower, *Helianthus annuus*, along the roadside, mile after mile. A few weeks later I noticed abandoned farmland had become a jungle of these sunflowers reaching above head height. Although no-tillage farming usually implies use of perennials, this sunflower and some of its relatives are annuals that can naturally reseed year after year without plowing. These hardy plants thrive in disturbed habitats, although best at elevations above the desert or in home gardens. The wild sunflower is late ripening, in fall after most summer crops have been harvested. Native Americans made extensive use of the "seeds," actually an achene, which includes the husk and its enclosed seed.

This wild sunflower, native across North America, is the progenitor of domesticated, agronomic varieties, with a very large and often single seed head, larger seeds, and different cultivars bred for thinner shells and high seed oil. Russia and the Ukraine produced 16 million tons of sunflower seeds last year—that's 32 billion pounds. The wild sunflower differs in part by having smaller but numerous flower heads, smaller achenes/seeds, and a much wider range of ecological tolerance. Simple commercial and artisanal methods of harvesting and cleaning are well known. In early October, New Mexico Gila River farmer Eric Leahy collected wild sunflowers from an abandoned field and showed us how to separate the achenes from the chaff using screens, and further winnowing using a fan. Apaches and others ground the whole achene, seed and husk together, for an esteemed food resource. Some people boiled the achenes whole and, after cooling, the oil would be skimmed off, providing sunflower oil. Why not farm these plants? It would be more like managing a sunflower-filled land.

The Sonoran Region native bounty extends to grasses, too. Civilizations co-evolved with grasses: wheat, rice, corn, oats, barley, sorghum, and a richness of others. But these familiar crops are tropical and temperate-climate plants—requiring extensive irrigation in dry regions. They are also annuals, which require annual replanting and tillage (plowing). What if we developed arid-adapted no-tillage grain crops? One intriguing candidate is nipa (*Distichlis palmeri*) at the Colorado River delta, one of the very few grasses endemic to the Sonoran Desert. Nipa was a staple of the Cocopah people, thrives with pure seawater, and produces prodigious amounts of grain comparable to that of early strains of rice.

Most grass grain (technically a caryopsis, a seed fused to the fruit case, or pericarp) are edible, although many are too difficult to prepare or process. (However, avoid ergot-contaminated or otherwise infected grain, which will stand out as discolored and much larger than uninfected grain. Also, ensure proper storage to preclude the growth of fungi that produce mycotoxins.) Many Sonoran region grasses make up for being small by producing large quantities of

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Arizona Native Food Plants for a Dry Future *continued*

grain and, like many arid land plants, pack a lot of energy into their seeds. The Comcaac (Seri people) even harvested the minute grain of the six-weeks grama grasses (*Bouteloua aristidoides* and *B. barbata* var. *barbata*), which can carpet the desert after summer rains.

For home gardens and agriculture, we turn to some interesting perennial grasses. *Sporobolus* species are unusual among grasses because the actual seed ripens free from the surrounding pericarp and chaff (glumes, lemma, and palea), thus giving rise to the common name "dropseed grasses." Perennial dropseed grasses, such as *S. cryptandrus* and especially *S. giganteus*, have seeds so minute as to be like flour. It is certainly possible that these seeds could be used like flour, without milling, because the surface-volume ratio is already very high.

Twila Cassadore, native food expert of the San Carlos Apache Tribe tells us the grain of *Panicum bulbosum* (*Zuloagaea bulbosa*) is the easiest to harvest and best tasting of the wild grasses. The Apache name translates as Red Grass, a more enticing name than bulb panicgrass; let's call it Apache Red Grass. Indeed the ripening panicles are usually reddish and the freshly harvested grain has a pleasant taste.

Apache Red Grass is a large perennial grass native to mountains in the Southwest and northern Mexico. The grain is like that of the related Common Millet, *Panicum miliaceum*, albeit smaller. You can easily strip off the ripe Red Grass grain by hand into a paper bag. Like other grains and seeds, it is essential to get them dry as soon as possible—all moldy seeds and grains need to be avoided. You can prepare it as you would any millet or small grain. Like many wild grasses and millets, Apache Red Grass grain is gluten-free.

Some Apache Red Grass plants have bluish-green foliage while others have yellow-green or bright green foliage, making them attractive landscape plants as well as a tasty food resource. Red Grass can be grown from seed or divisions of the short rhizomes of established plants. To get good seed set and ensure cross-pollination you should have more than one clone. Plant it along a walkway, as an accent plant, or backdrop screen, or in an experimental plot for grain production. The above-ground parts are frost-killed but remain as fall color in your garden, or cut the above-ground part and this perennial will resprout in spring.

Gregg Dugan harvesting Apache Red Grass, Pinos Altos Mountains, New Mexico, 10 September 2014. *Photo by Jarrod Swackhamer.*

The coconut, oil palms, and date palm are among the more significant human food resources. The date, *Phoenix dactylifera*, is the desert palm of Egypt, but what about our desert palms? *Washingtonia filifera,* in desert oases and canyons in Arizona, California, Nevada, and Baja California, is the only palm native to the western United States. Its only close relative, *W. robusta*, is native to Sonora and the Baja California Peninsula. These fan palms are grown across the Sonoran Desert Region and arid/subtropical regions around the world. The fruit, produced in prodigious quantity, is similar to that of the date palm but much smaller, often only 6 mm long. Palm expert Don Hodel of the University of California Cooperative Extension found that a single *W. robusta* produced approximately 572,000 fruits weighing 101 kilograms (223 pounds). The Cahuillas of Palm Springs, California, made extensive use of the sweet fruit of *W. filifera*, fresh or dried, for beverages, or the whole fruit and seed ground into flour. Fine preserves and especially beverages might be the best modern-day applications, or as local food expert Carolyn Niethammer suggests, perhaps for baked goods instead of sugar or corn syrup, or a source for a granulated natural sweetner. Try experimenting with these fan palm fruits.

Palms require water, but like many other large monocots, the root system is not extensive. You only need to provide water close to the trunk, and poor-quality water will suffice, such as gray water, or water too alkaline or saline for other plants. You will need an extension pole, bucket lift, or some other way to harvest high-hanging fruit.

Any new agronomic crop faces challenges — observations, experimenting, serendipity, perseverance, and creativity can give results. Incentives for our own arid-adapted food crops

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include adapting to a warming and drying climate, water shortages, energy conservation, more sophisticated consumers, and improved nutrition in everyday diet.

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Left: A view of Sierra Mazatán. Right: Chihuahuan oak. *Photos by Thomas R. Van Devender.*

Oaks, Cycads, Orchids, and Conservation in the Sierra Huérfana, Sonora

by Thomas R. Van Devender[1], J. Jesús Sánchez-Escalante[2], and Ana L. Reina-Guerrero[1]

The southwestern most Sky Island in Sonora is 80 km west of Hermosillo, a city of about a million inhabitants. It is called the Sierra Mazatán by the residents of Mazatán (from a Nahuatl Indian word meaning "place of deer" – the same as Mazatlán). But most of the mountain is in the Comunidad Agraria de Pueblo de Álamos, where it is Sierra Huérfana — or Orphan Mountain — a good name for a Sky Island! It is surrounded by tropical foothills thornscrub just east of the Sonoran Desert, with oak woodland on top in a landscape of whitish granite boulders.

The flora of the Sierra Huérfana, with reliable summer rains and granitic soils that hold moisture very well, is unique. Sanchez-E. et al. (in 2005) reported 357 species in a preliminary flora. Documentation of the flora is still in progress and a more complete flora will be published soon. The oak woodland is dominated by Chihuahua and willowleaf oaks, often festooned with ball moss (*Tillandsia recurvata*). Various thornscrub plants, including *papelío* (*Jatropha cordata*), kapok/*pochote* (*Ceiba acuminata*), *torotes* (*Bursera fagaroides, B. laxiflora*), and tree ocotillo (*Fouquieria macdougalii*) reach their upper elevational limits in this woodland.

In May 1957, Howard S. Gentry, the pioneering botanist who worked in the Río Mayo Region of tropical southern Sonora, collected a cycad in the Sierra Huérfana. In 1997, it was described as *Dioon sonorense,* a species endemic to Sonora and northern Sinaloa. *Palma de la vírgen* or *peine* (the serrated leaf edge looks like a comb) occurs in 5-6 populations in Sonora, and has a *Protegida* status under the 2010 Mexican endangered species law. There are 14 species of *Dioon* from Nicaragua northwest into Mexico. The Sierra Huérfana *D. sonorense* are the northernmost cycads in the world. During the Triassic and Jurassic geologic periods 200 to 145 million years ago, cycad trees and shrubs along with conifers and ginkos dominated archaic dinosaur forests. Although cycads were once widely distributed over the Earth, including Alaska and Antarctica, the family Zamiaceae today only contains eight genera in Africa, Australia, and North and South America.

Other unusual plants in the Sierra Huérfana include the endemic Mazatán rock daisy (*Perityle reinana,* named in honor of Ana Lilia Reina-Guererro), coral root orchids (*Hexalectris spicata* var. *arizonica, H. warnockii,* only Sonoran locations), a white morning glory/*trompillo* (*Ipomoea scopulorum*), and tiger flower (*Tigidia pavonia*). The red-flowered claret cup cacti in the Sierra Huérfana are mostly *Echinocereus santaritensis* var. *bacanorensis,* a southern, summer-flowering variety of the Santa Rita Mountains claret cup. There is also a record of *E. klapperi,* a rare species only known from here and near the El Novillo reservoir.

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Above, left: *Dioon sonorense*, detail of serrated leaf edge. *Photo by by Ana L. Reina-G.* Center: *Hexalectris spicata* and Right: *H. warnockii*, coral root orchids. *Photos by Michael F. Wilson.* Below: Evening meeting of Pueblo de Álamos residents, CONANP personnel, and MABA participants to discuss the proposed Sierra Huérfana Protected Natural Area. *Photo by James Rorabaugh.*

Oaks, Cycads, Orchids *continued*

The Comisión Nacional de Áreas Naturales Protegidas (CONANP, the Mexican Park Service), is working on establishing the Sierra Huérfana as a federally-protected natural area. Pueblo de Álamos is a *comunidad agraria,* a federal designation that recognizes historical residence and land rights in an area. *Comuneros* use and manage the land, but cannot sell it. Otherwise the prime woodlands of Sierra Huérfana, so close to Hermosillo in the Sonoran Desert, would have been developed long ago.

In April 2014, 55 botanists, entomologists, herpetologists, and ornithologists, as well as agency biologists, photographers, journalists, and college students from the United States and Mexico joined local residents on a Madrean Archipelago Biodiversity Assessment (MABA) Expedition to the Sierra Huérfana. Over 1,000 biological observations were made and added to the MABA database (Madrean.org), providing documentation of the unique biodiversity of this Sky Island (*Isla Serrana* in Spanish). The group's exuberant appreciation of natural history was contagious, and in July the residents of Pueblo de Álamos voted in favor of the new Áreas Naturales Protegidas.

We thank the Greater Good Foundation for support for the MABA Expedition.



Above: White-flowered morning glory (left) and Tiger flower (center). *Photos by Erik Enderson.* Right: Bacanora claret cup cactus. *Photo by Stephen L. Minter.*



Left: *Polygala rusbyi*, a central Arizona endemic growing on dolostone. Center: Upper Verde River flowing through Cambrian Tapeats sandstone below Devonian Martin dolostone. Right: *Salvia dorrii* ssp. *mearnsii*, a Verde Valley and Upper Verde River endemic growing on dolostone. *Photos by Francis S. Coburn.*

Special Soils and their Role in Plant Evolution, Distribution, and Regional Diversity:

Examples from the Upper Verde River, Arizona

by Francis S. Coburn[1]

Geology and soils have been cited as second only to climate as the primary determinants of plant distribution and diversity (Cain 1944). The stark contrast between plant communities of distinct geologic formations has long fascinated naturalists, ecologists and evolutionary biologists. Theophrastus (ca. 380-287 B.C.), the "Father of Botany" was one of the first to record a singular vegetation type growing on limestone bedrock in ancient Greece. In some of the first published articles on natural selection, Wallace (1858) spoke of the high degree of selection imposed on plants by their substrata. Throughout the globe, managers and researchers have become increasingly interested in the effect of geology on plant distribution, endemism, and regional diversity.

Infertile soils in particular have drawn attention. They often form islands with distinct plant communities, host disjunct species, and drive the evolution of rare and endemic species. Major examples include serpentine, which is low in nutrients and high in toxic metals, and the highly basic and low nutrient limestones, dolostone (a magnesium limestone) and gypsum. Other examples include mine tailings, various igneous and sedimentary rocks, sand, clay, and saline soils. On top of harsh chemistry, the physical nature of some of these soils can create stressful conditions, being impenetrable to plant roots, and steep or rocky.

Edaphic endemics have morphological and physiological features that allow them to cope with harsh conditions. Among these are perennial growth form, small stature, low specific leaf area, high root to shoot ratio, low growth rates, stress-related leaf characteristics (glaucousness, pubescence, sclerophylly) and mutualistic relationships with soil organisms. These traits allow them to tolerate drought and thrive with relatively low amounts of nutrients (Kruckeberg 2004).

The presence of disjuncts and endemics on edaphic islands tell stories of the biogeographical and evolutionary history of a region. Two main paths to endemism have been identified; paleoendemics are relicts of older, more widespread species while neoendemics have diverged more recently. Throughout North America since the late Tertiary and Pleistocene, plant migrations and radiations have tracked dramatic climatic and topographic shifts (Axelrod 1958, Betancourt et al. 1990). Over time the ranges of species less fit for the changing climate retracted as they were outcompeted by the incoming dominant vegetation. Plants that were poor competitors but were able to survive on infertile islands were released from competition and able to persist, while they were extirpated on surrounding soils. These refugial populations exist today as disjuncts,

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Left: *Escobaria missouriensis*, a disjunct primarily from the Great Plains growing on dolostone. Right: Layers of the Supai group on top of cliffs of Redwall limestone at Perkinsville, Arizona. *Photos by Francis S. Coburn.*

Special Soils and their Role *continued*

populations at the periphery of their ranges and in the case of plants that have been extirpated everywhere else, paleoendemics. Some populations that persisted on the edaphic islands became more adapted to the soil environment, forming ecotypes, and over time became increasingly isolated, leading to speciation and the neoendemics seen today (Stebbins and Major 1965, Kruckeberg 2004).

Other neoendemics arose when individuals of species growing off of infertile soils possessed traits allowing them to cope with infertile soils and colonized an edaphic island. Many of these transitions were associated with hybridization and polyploidy events and coupled with other genetic changes such as shifts in flowering time, driving reproductive isolation and speciation in species with the same ranges (sympatric speciation) (Rajakaruna 2004). These are a sample of the processes that have led to the high amount of endemism on infertile soils.

Geologic formations and their endemic inhabitants contribute to regional diversity in many parts of the world. They contribute significantly to the high rates of endemism in "biodiversity hotspots" such as the California and Cape Floristic Provinces. In the arid Southwest United States and Northern Mexico, geologic richness has given rise to substrate-specific floras and edaphic endemics including those of gypsum and limestone in the Chihuahuan Desert (Van Devender et al. 2013, Escudero et al. 2014), the fresh-water limestones of the Sonoran Desert (Anderson 1996, 2011) and plants of various sedimentary formations on the Colorado Plateau. Many of the Southwest's rare endemic species occur on specific substrates and the presence of geological diversity significantly increases the plant species diversity of the region's deserts.

The Upper Verde River

The region surrounding the Central and Upper Verde River of Arizona is yet another example of an area rich in geological and botanical diversity. Abundant faulting resulted in uplifts of ancient igneous formations and Paleozoic sedimentary formations. Volcanos dotted the landscape and lava flows formed mesas and plugs that dammed streams, resulting in large freshwater lakes that persisted for thousands of years in which layers of freshwater limestone accumulated. This formed the patchy mosaic of geology and scenic landforms that can be seen today.

As part of a Master's Thesis at Arizona State University, I have been conducting a floristic inventory of the Upper Verde River region. Over 12 geologic formations exist in the area and sharp distinctions in plant species have been observed between the limestones (Devonian Martin Formation Dolostone [440-400 Ma], Paleozoic Redwall, Supai Group [380-260 Ma] and Tertiary Verde formation [7-2 Ma]) and a small patch of Paleozoic sedimentary Tapeats Sandstone (700-400Ma) and two very old igneous formations (Gabbro [>1500Ma] and Verde Granite[1700Ma]). Many species on these formations show patterns of disjunction and endemism classically associated with edaphic islands.

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Special Soils and their Role *continued*

Left: *Chamaesyce dioica*, a disjunct from southern Arizona and Northern Mexico growing in granite. Right: *Eremogone aberrans*, a central-northern Arizona endemic growing on granite. *Photos by Francis S. Coburn.*

To date, 55 species of the approximately 700 species in the Upper Verde River area are found to grow exclusively on limestones. Of these, 29 are populations at the periphery of their ranges, 15 are disjuncts, and 10 are regional endemics. The limestones, particularly the Devonian Martin Dolostone and Tertiary Verde Formation, host many peripheral populations and disjuncts, primarily from the northern Great Basin Desert and Colorado Plateau with a few species from the southern Chihuahuan Desert. Notable examples from the north include dwarf sand verbena, *Abronia nana* (Nyctaginaceae), a disjunct primarily from the Great Basin Desert with ca. 100 miles to its nearest population in the Grand Canyon, and Missouri foxtail cactus, *Escobaria (Coryphantha) missouriensis* (Cactaceae), a disjunct most common in the Great Plains of Wyoming and disjunct ca. 125 miles from populations on the Arizona Strip. The limestones and Martin formation Dolostone host at least 10 central Arizona endemics, five of which are US Forest Service Sensitive and one, *Purshia subintegra* (Rosaceae), federally Endangered. These contribute to the area's having one of the highest densities of endemics anywhere in Arizona (Salywon et al. 2013). Notable sensitive endemics include Mearns' Sage, *Salvia dorrii* subsp. *mearnsii* (Lamiaceae), an endemic of the Verde Valley and Upper Verde River, Rusby's milkwort, *Polygala rusbyi* (Polygalaceae), an endemic spanning from the Verde Valley northwest along the Upper Verde River to the Hualapai Reservation and *Pediomelum verdiense* (Fabaceae), a recently described endemic to the Verde Valley and Upper Verde River.

To date, 32 species from the Upper Verde River are found to grow exclusively on the Verde granite, gabbro, and Tapeats sandstone, of which 14 are marginal populations, 17 are disjuncts and one a central Arizona endemic: Mt. Dellenbaugh sandwort, *Eremogone aberrans* (Caryophyllaceae). Peripheral populations and disjuncts growing on these formations, as opposed to the northern affinity of limestone plants, have centers of distribution in southeastern Arizona and northern Mexico, with multiple species disjunct from the Sonoran and Mojave Deserts. Examples include harlequin spiralseed, *Schistophragma intermedia* (Plantaginaceae), a disjunct with populations near Payson, ca. 80 miles to the southwest but otherwise with a center of distribution in southeast Arizona, 240 miles away, and royal sandmat, *Chamaesyce dioica* (Euphorbiaceae), a disjunct primarily from 200 miles to the south.

The limestone affiliated species represent >10% of the flora, and the contribution from other edaphic formations contribute another 5%. Further analysis will bring to light the contributions of basalt formations, which have not yet been analyzed. Clearly, distinct geological formations contribute significantly to the species richness of the region.

The geologic diversity and its relationships to plant species diversity and distributions along the Upper Verde River undoubtedly hold evidence of the historic biogeography and plant evolution in the region. Since multiple species associated with a particular rock type have centers of distribution in common, it is plausible they may be relicts of past migrations and dominant vegetation types, since there is a low probability each species distributed to the soil type independently over time. On the other hand, on the scale of thousands of years, species may have had the time enough disperse, one by one to these islands and form similar assemblages to their centers of distribution. Population genetic and phylogeographic studies combined with tools such as climate and species distribution (niche) modeling could help to clarify the causes and history behind these patterns.

The patterns seen here of endemism are also in need of further study. Although many groups inhabiting both the serpentine of California and gypsum of the Chihuahuan Desert floras are becoming well studied, little has been done to address the systematics, adaptation, speciation, and biogeography of edaphic endemics on limestone and dolostone in central Arizona. It is likely most of the

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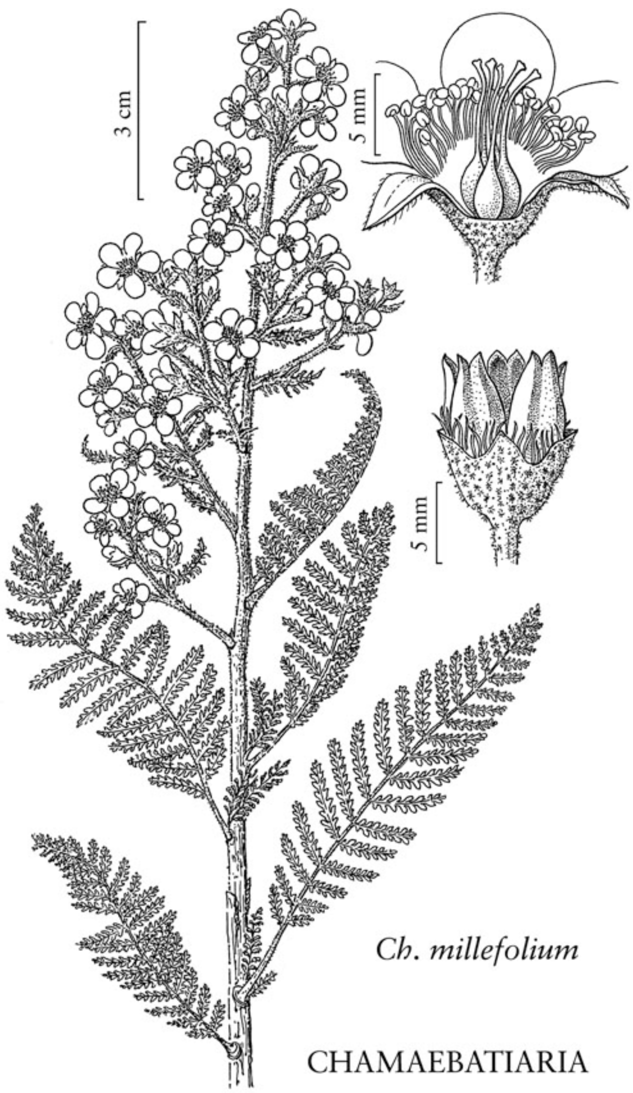
Flora of North America Honors the Arizona Native Plant Society

The Flora of North America (FNA) project recently honored the Arizona Native Plant Society by dedicating a beautiful illustration of *Chamaebatiaria millefolium*, Rosaceae, (Fern Bush) to the Society. Accompanying the notice of the dedication was an archival quality print of the illustration by the gifted botanical artist Marjorie Leggitt. The illustration will appear in the upcoming Volume 9 of the FNA.



The following information from the FNA website (**floranorthamerica.org**) describes the scope of this major botanical undertaking:

> *The Flora of North America project builds upon the cumulative wealth of information acquired since botanical studies began in the United States and Canada more than two centuries ago. Recent research has been integrated with historical studies, so that the Flora of North America is a single-source synthesis of North American floristics. FNA has the full support of scientific botanical societies and is the botanical community's vehicle for synthesizing and presenting this information.*
>
> *The Flora of North America Project will treat more than 20,000 species of plants native or naturalized in North America north of Mexico, about 7% of the world's total. Both vascular plants and bryophytes are included.*
>
> *Species descriptions are written and reviewed by experts from the systematic botanical community worldwide, based on original observations of living and herbarium specimens supplemented by a crucial review of the literature. Each treatment includes scientific and common names, taxonomic descriptions, identification keys, distribution maps, illustrations, summaries of habitat and geographic ranges, pertinent synonomy, chromosome numbers, phenology, ethnobotanical uses and toxicity, and other relevant biological information.*

AZNPS members may wish to order copies of individual volumes of FNA which are now available from the Oxford University Press at discount rates. You can order from **www.OUP.com/US** or telephone (800-451-7556, using the promo code 33009 to get the discount). Also, individual sponsorships for new illustrations may be purchased at **floranorthamerica.org**.

Special Soils and their Role *continued*

endemics of the region are neoendemics since many belong to widespread, diverse, rapidly radiating lineages (e.g. *Eriogonum and Salvia*) and paleoendemics typically belong to geographically restricted groups with low diversity. Phylogenetic and population genetic studies could resolve relationships within lineages, particularly between relatives growing on and off of limestone. This would provide insight into the timing of niche shifts, the speciation of endemics, and the climatic and geologic factors that led to their diversification and contribution to species diversity in the region.

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Characterization of the *Selaginella arizonica* x *eremophila* (Selaginellaceae) Hybrid Zone in Southern Arizona

by Anthony E. Baniaga[1] and Michael S. Barker[1]

Introduction

Botanists have long recognized the dynamic nature of plant genomes. Hybrid and polyploid taxa have been described from artificial crosses, morphological traits, cytology, isozymes, and more recently the incongruence between nuclear and plastid gene trees. However, the contribution of hybridization and polyploidization (aka whole genome duplication) to plant diversity has long been debated. The spectrum of opinions ranges from an ephemeral evolutionary dead end (Wagner 1970) to an omnipotent evolutionary process involved in adaptation to new environments (Lewontin & Birch 1966). At its core this debate reflects the tension between gradual versus punctuated evolutionary change.

At the University of Arizona in the Barker Lab we investigate the evolutionary genetic processes of hybridization and polyploidization through comparative genomic methods. We are currently generating a model system with natural populations of hybrid and polyploid desert adapted lycophytes in the genus *Selaginella* (Selaginellaceae). These plants commonly form large mats in association with rock outcrops, and they possess a complex integrated phenotype that allows them to resurrect from metabolic dormancy for short intervals following rainfall events.

The *Selaginella arizonica x eremophila* Hybrid Zone

In the Sonoran Desert of southern Arizona and northern Mexico two closely related species, *Selaginella arizonica* Maxon and *Selaginella eremophila* Maxon are found. These taxa are morphologically, ecologically, and for the most part geographically differentiated. However, in the transition zone between the Arizona Upland and Lower Colorado Valley vegetation divisions (Shreve & Wiggins 1951) they do form fertile hybrids. This area corresponds with the mountainous areas east and west of Arizona State Highway 85, which runs from the U.S. Mexico border at Lukeville to Buckeye west of Phoenix.

Hybridization between *S. arizonica* and *S. eremophila* was hypothesized decades ago based on morphological intermediates in the field and mysterious mixed collections on herbarium sheets. This hybridization hypothesis was further supported as an example of homoploid hybrid speciation from biparental isozyme expression patterns (Therrien 2004).

Currently, based on work by members of the Barker Lab and others (Windham & Yatskivetch 2009; Felger et al. 2013), several putative diploid hybrid populations as well as one putative allotetraploid population have been located throughout the hybrid zone. In order to complement our evolutionary genetic studies, an ecological characterization of the *Selaginella arizonica x eremophila* hybrid zone was performed from field surveys and herbarium specimens. These characterizations include a quantification of morphological differences, climatic niche differences, as well as predicted occurrences of parental and hybrid taxa in southern Arizona.

Methods and Results

Morphology

A morphological analysis was performed in order to quantify inter- and intraspecific variation of the two parental and hybrid taxa. The morphological traits examined include terminal and axillary seta shape, texture and length; microphyll width and length; internode length; rhizophore density; and strobili length. At least five measurements were made per herbarium sheet for each trait under a dissecting microscope. All available voucher specimens deposited at the University of Arizona and Arizona State University herbaria found within the vicinity of the hybrid zone, as well as a random subset of three parental samples outside of the hybrid zone were examined. These were supplemented by field observations and collections from 2012-2014.

Of the morphological traits examined, hybrids consistently have intermediate character values for adaxial microphyll length and terminal seta traits such as shape, and texture

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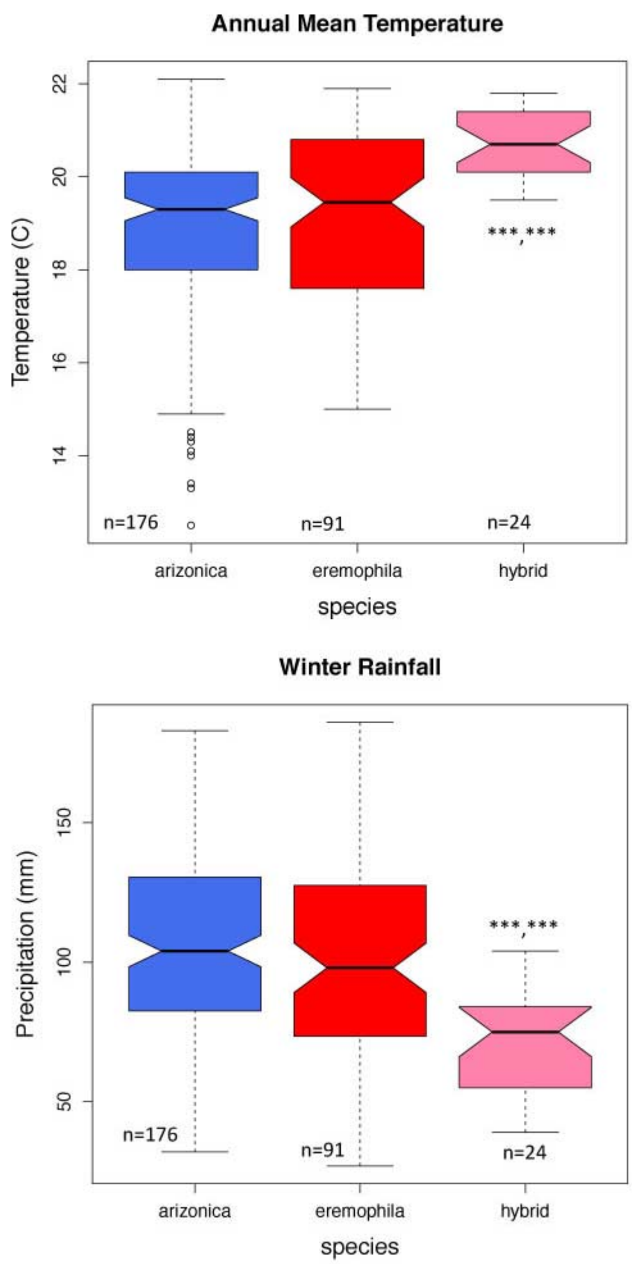
Table 1. Descriptions of important morphological differences between *Selaginella* taxa.

Taxon	Adaxial microphyll length (mm)	Terminal setae shape and texture
S. arizonica Maxon	(1.7) 1.9-2.3 (2.8)	Stout, straight; serrate, usually persistent
S. eremophila Maxon	(0.8) 1.3-1.5 (1.7)	Delicate, pigtailed to contorted; smooth, deciduous with age
S. arizonica x *eremophila*	(1.1) 1.6-2.0 (2.6)	Slender, sigmoidal; usually smooth, often forked at tip; +/- persistent



Selaginella arizonica *continued*

(Table 1). These terminal seta characters are delicate and best observed in newly formed microphylls (Tryon 1955; Yatskivetch & Windham 2009). Interestingly, unique morphological variation is found in the hybrids from the southern populations of Ajo, Cabeza Prieta, and Organ Pipe Cactus National Monument. In these individuals, the terminal seta is often forked at the distal tip. This character is not observed from hybrid individuals around Phoenix.

Hybrid Climatic Niche and Occurrence Prediction

All available records throughout the entire range of *S. arizonica*, *S. eremophila*, and *S. arizonica x eremophila* were collated from SEINet, the California Consortium of Herbaria, and the Global Biodiversity Information Facility. These records were manually verified, georeferenced, and the associated 19 bioclimatic variables at 30 arc-second resolution (Hijmans et al. 2005) were extracted and compared.

Of the bioclimatic variables included in the analysis, annual mean temperature and winter precipitation were significantly different between the hybrids and both parents. Based on a Wilcoxon rank sum test, hybrids are found in locations that are on average warmer and drier than either of the parents (Figure 1).

These bioclimatic variables were also used in a MaxEnt framework to predict regions with a high probability of occurrence of hybrids. Four different types of model predictions were made; *S. arizonica*, *S. eremophila*, *S. arizonica* + *S. eremophila* (parents lumped into one dataset), and all known localities of *S. arizonica x eremophila*.

The four different models revealed a high probability of occurrence of hybrids in the known hybrid zone, and overlapped with all known localites of hybrid populations. The prediction models did highlight a high probability of hybrids in the Batamote Mountains east of Ajo, and the northern Maricopa Mountains of the Sonoran Desert National Monument of which there are no known observations of any *Selaginella* taxa. Interestingly, these models also highlighted a high

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Figure 1: Hybrid climatic niche differentiation. Annual mean temperature (°C) ($p < 0.001$), and winter precipitation (mm) ($p < 0.001$), Wilcoxon rank sum test. Notches represent median values and asterisks represent significantly different comparisons to parental taxa ($p < 0.05$).

probability of hybrid occurrence outside the known hybrid zone in an unexpected region to the northwest. Only *S. arizonica* is known from this general region, which includes the Kofa, Little Horn, Harquahala, and Harcuvar Mountains.

Summary

The *Selaginella arizonica x eremophila* hybrid zone can be characterized in three main ways. First, hybrids can be recognized via a combination of intermediate morphological characters related to adaxial microphyll length, and seta shape and texture. Setae traits appear less labile to environmental effects and are the single best indicator of hybrid taxa. Second, the hybrid climatic niche is significantly warmer and drier than either of the parents. Finally, the hybrid zone is associated with the transitional zone between the Arizona Upland and Lower Colorado Valley vegetation divisions which corresponds with Arizona State Highway 85 and may extend northwestward along the Interstate Highway 10 corridor.

Whether hybrids and polyploids are found in marginal habitats relative to the parents or have adapted faster to a new habitat is an open and important question. In addition to field surveys, we are testing hypotheses concerning the multiple origins of hybrid and polyploid taxa, as well as measuring relevant ecophysiological traits in this system.

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Who's Who at AZNPS

SPOTLIGHT ON A NATIVE PLANT

Mexican Tansyaster (*Psilactis gentryi*)

by Bob Herrmann, Cochise Chapter, Arizona Native Plant Society

The Mexican Tansyaster (*Psilactis gentryi*) is a beautiful native wildflower that reaches the northern end of its range in the Huachuca Mountains, its only known occurrence in Arizona. In Mexico it occurs as far south as the State of Durango. In the Huachucas it's an occasional annual that grows up to 2 feet tall and produces beautiful 3/4 inch blue to purple flowers. The leaves are alternate lanceolate which distinguishes the species from other blue-flowering asters in the Huachucas. It prefers moist habitats in canyon bottoms and along rocky streambeds ranging in elevation from six to nine thousand feet. The plant has hairy, slightly glandular stems and leaves, starts growing in June, and flowers from September through November.

The genus *Psilactis* consists of six species, five of which occur in the southwestern United States. Two of the five U.S. species occur in Arizona: *P. gentryi* and *P. asteroids*. The genus *Psilactis* was described by Asa Gray in 1849, its name being derived from the Greek *psilos* meaning naked and *aktis*, meaning ray, referring to the fact that the ray akenes lack a pappus. The species name honors Howard S. Gentry, a U.S. Department of Agriculture botanist who collected extensively in northwestern Mexico and later was a research botanist with the Desert Botanical Garden in Phoenix.

Caught in this photograph sharing a sip of Mexican Tansyaster nectar is a European immigrant, the Wool Carder Bee (*Anthidium manicatum*) and an Arizona native, the Gray Bee Fly (*Anastoechus melanohalteralis*). The Wool Carder Bee is a solitary bee, so named because the female bee collects plant hairs and makes her nest appear to be wool lined. The Gray Bee Fly is named for its color and bee-like appearance. The female fly seeks out grasshopper egg-pods that her maggots then feed upon. I have photographed several other varieties of bees and butterflies pollinating the flowers of the Mexican Tanseyaster. As only an occasional annual it may take some time to find it but the search is well worth the effort.

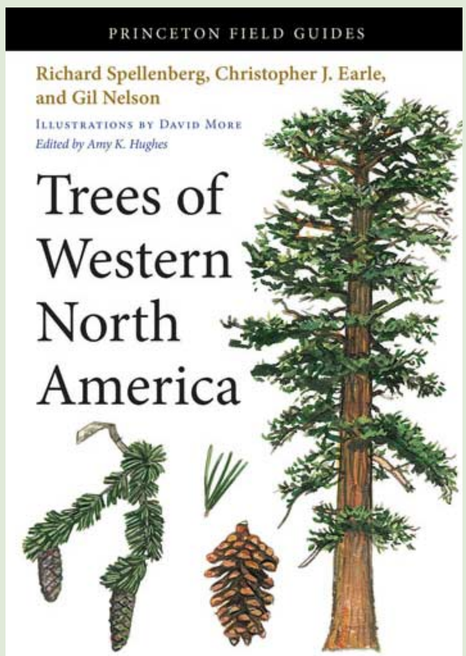
BOOK REVIEW *by George M. Ferguson, University of Arizona Herbarium and Arizona Native Plant Society, Tucson Chapter*

Trees of Western North America

by R. Spellenberg, C.J. Earle, and G. Nelson, edited by A.K. Hughes

Princeton University Press. 560 pp. July 2014. ISBN 978-0-691-14580-8. Paperback Flexibound: **$29.95**

New in the series of Princeton Field Guides, *Trees of Western North America* is a most definitive compact book, designed for easy use in the field. It complements a parallel release: *Trees of Eastern North America* by another combination of the same authors at the same price (for paperback with a firm binding). Both are also available in hardcover. For anyone interested in tree-like plants in the West, the *Trees of Western North America* is it, covering 630 species west of the 100th meridian, and rightly proclaiming itself to be the most comprehensive, best illustrated, and easiest-to-use book of its kind.



The prize is in the detail. Simply arranged to keep you from getting lost in the forest of information, each tree entry is presented in taxonomic order. If you think you know the plant family, there is no need to search the index of common and scientific names combined. But, to facilitate determination of a species, a pictorial leaf-key is presented at the front of the book, designed for you with leaf-in-hand, to find a species match within the book. Atop every page of tree entries is a color-coded header for the family in both Latin and vernacular, e.g. "Fabaceae: Bean or Pea Family." Subsequent genera and species are covered alphabetically by scientific name within the family. Pages opposite the tree entries contain meticulous color drawings by David More, depicting key features of tree habit, leaf shape, fruit and flower as well as the bark. Subtleties of texture and color shade are superbly conveyed. On the same page with the descriptive text, are precisely detailed distribution maps for each species. These are reminiscent of the USDA maps based on those by arborist Elbert L. Little, Jr.

Descriptions for every native or naturalized tree-like species in the West are accurately written for even the most demanding botanist, yet in layman's terms. Wonderful panels with expert botanical summaries start the description of each family and each genus. Tree taxon entries are standardized. Thus consistent terms are used and appear in the same order throughout, beginning with a single, best, common name, followed by the scientific name, then "a.k.a." alternate common names, if any. Next, a "Quick ID" sentence in boldface summarizes traits uniquely delineating the species in the region it occurs. Following this, an easy to read paragraph describes the bark, twig, leaf, fruit or cone, and for flowering plants, the flower, all in metric units. Still not convinced of your ID? There's more.

In compiling this book, the authors' expertise shines through in the "Similar Species" paragraphs and "Notes" sections of each tree entry. Fine details for determining whether you have the right species are found there, as well as explanations of up-to-date nomenclature, including differing scientists' views on the species, if any, or evidence of intergradation and hybridization. There is also information about the plant's uses, and whether it is considered poisonous. A most useful statement under "Habitat/Range" is provided for each entry, beginning with either "Native" or "Introduced" (and from where). It includes elevations in meters, in which States the species occur, including Alaska and Canadian Provinces (even if just a handful tree species grow there), and whether that taxon extends beyond the map boundary to the eastern U.S. or Mexico.

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Trees of Western North America *continued*

What's a tree? The authors state there is no scientific difference between a tree and a shrub. Though a tree should have a single woody stem and a crown of branches, a broader definition of a tree is taken here. It includes plants generally taller than a human, often with multiple woody trunks, and plants that may be thought of as shrubs. So, sagebrush, cholla and prickly pear cacti, nolinas and yuccas are included in the book as well as many small overlooked species usually considered shrubs. Likewise, species, local or endemic to narrow regions, are not neglected, *e.g.* Oregon coast trees, Channel Island natives, borderlands plants of San Diego County, and rare species of southern Arizona, or Big Bend and the lower Rio Grande Valley of Texas.

Complex and difficult genera are treated in this book so they appear easy; such as the willows, with nearly 30 species in the West; hawthorns, another 25 to 30 species, some of which are hybrids; not to mention the oaks, comprising about 48 species in the West. And, seven species of introduced tamarisk are covered. The booming business of nomenclature change is addressed effectively with new family alignments, and generic rearrangements adopted. The authors relied on these references: *Flora of North America* (**eFloras.org**), the PLANTS Database (USDA) as well as recent technical literature. For example, the former New World *Acacia* genus in the book is split into three other genera, *Mariosousa*, *Senegalia*, and *Vachellia*, and some of the genus *Rhamnus* species are now represented in this book as *Frangula*.

Despite all the wonderful aspects of this magnificent new book, perhaps wishful improvements would include the fascinating diversity, foreign and native, of Hawaii. At least some indication is given if a species occurs in Mexico, otherwise it stops at the border! While coverage of many landscape shrubs and trees is welcomed, a few native trees were left out, such as species of tree-like *Berberis*, *Coursetia* and *Erythrina* in Arizona. Perhaps some more common ornamental trees, such as other *Senna* and *Pinus halepensis* should have been included. Several of the native pines are poorly portrayed. A few typographical errors exist, *e.g.* "mm" instead of "cm" in a few entries; obvious portions of ranges missing from some maps, though stated correctly in the text; and, in a few, probable measurement discrepancies such as tree height.

Overall, this book makes the grade "A" in nearly every aspect of presentation; it is tremendously useful, navigable, readable, highly accurate and immensely informative. The added perks, such as the family and genus panels, glossary, essays on The Biggest Trees, Pine Ecology, Forests and Climate Change, the 20 page introduction to Tree Biology, Taxonomy and Names, Forest Structure and the expertly illustrated leaf keys only increase its usefulness, functionality, and value.

Many Thanks to Marilyn Hanson

Long-time Tucson Chapter member and AZNPS webmaster Marilyn Hanson recently turned her webmaster duties over to Cass Blodgett, co-president of the Phoenix Chapter. For many years Marilyn did a superb job of maintaining the Society's website as well as performing numerous other duties for the Tucson Chapter. She has also had a profound positive impact on native plant conservation by serving as the indefatigable volunteer coordinator for the Sonoran Desert Weedwackers, the AZNPS partner organization responsible for eradicating bufflegrass and other noxious species from many critical Sonoran Desert habitats. We sincerely thank Marilyn for her many contributions to the Arizona Native Plant Society and look forward to her continued efforts to help achieve the Society's plant conservation goals.

Announcing the 2015 Arizona Botany Meeting

April 25-26, 2015 — Museum of Northern Arizona, Flagstaff

Please plan to attend The Arizona Native Plant Society's 2015 Arizona Botany Meeting, which will be held in the beautiful and historic Branigar/Chase Discovery Center at the Museum of Northern Arizona, Flagstaff.

The theme for the conference is: "Ethnobotany: Past, Present and Future." Presentations and poster sessions will be delivered at the Museum on Saturday, April 25, and several field trips will be conducted on Sunday, April 26. Please consult the AZNPS website for the formal call for presentations and posters, meeting schedules, and registration information.

Congratulations to Cass Blodgett

In the summer of 2014 Cox Enterprises and The Trust for Public Land (TPL) selected AZNPS Phoenix Chapter co-president Cass Blodgett as a finalist for the Cox Conserves Heroes Award in recognition of his volunteer efforts to create, preserve or enhance the shared outdoor places in local communities. Cass was selected for his outstanding work as a volunteer citizen scientist on the North Mountain Plant Inventory Project. Through that on-going work he collects and documents North Mountain's diversity of flora, teaches the public about the native flora, and leads interpretative hikes. As a long-time member of the AZNPS, Cass has made many other contributions to the Society by serving as co-president of the Phoenix Chapter, helping to organize monthly meetings, leading field trips, recently becoming the AZNPS webmaster, and participating in many other efforts to raise the awareness of native plants and the importance of their conservation. Cass' nomination included a $2,500 award which he designated to the AZNPS. Thank you Cass!

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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

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