The Arizona Native Plant Society

The Plant Press

THE ARIZONA NATIVE PLANT SOCIETY

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In this Issue:

Biodiversity: Resiliency in Our Native Ecosystems

& Our Regular Features:

Printed on recycled paper.

above *Aquilegia caerulea,* Rocky Mountain Columbine.

The Diversity of Western Flowers

by Gwendolyn Waring[1]*. Photos courtesy the author.*

If you look at a topographical map of the United States, you'll see that the landscape of the West is very complex: there's lots of topographical relief. The West has recently had so many major geological events that on this map it looks very much like a crumpled up piece of paper, while the rest of the country is pretty flat by comparison. In the last 70 million years, the West has undergone the formation of the Rockies, the Sierra Nevada, the Cascades, the coastal ranges, the Great Basin basins and ranges, and the rising up of the Colorado Plateau. These events have had a huge effect on plant diversity. Distinctive soils such as shales or salt beds from old Pleistocene lakes have given rise to endemic types of penstemons, buckwheats and Indian paintbrushes, just to name a few. And such mountainous terrain isolates populations of plants and animals, helping them to diverge into new species.

There are some spectacular examples of groups of flowers that have radiated into many, many species only in the West, and often fairly recently. These diverse groups are a beautiful testament to the power of evolution, natural selection and the very tenacity of life itself. Here are a few examples and their stories. This essay is an excerpt from a book that I have recently written about western natural history. It is in review with Island Press.

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[1] Native Arts, Flagstaff, Arizona.

Special thanks from the editors to all who contributed time and efforts to this issue.

President's Note

by Barbara G. Phillips

Coconino, Kaibab and Prescott National Forests, Flagstaff **bgphillips@fs.fed.us**

Almost every morning before breakfast I walk my dog on a path through the forest and rocky oak hillsides to a mountain meadow with a wide open vista of the San Francisco Peaks. Parts of my route have been the same for the 32 years I have lived in Flagstaff, although I have lived in four different homes. I could say I'm walking to exercise my dog but, truth be told, I walk to preserve my spirit and my heart. The day just doesn't go as well if I haven't had my walk.

The different seasons bring such a variety of weather, plants, and animals. I ski the route in winter; slog through mud and rushing water in spring; an early morning shower catches me without a raincoat in summer; and then late fall brings ice crystals to every bit of leaf and fruit. I eagerly look forward to my "daily adventure" to keep in tune with the constantly changing natural world around me and never cease to be amazed.

Such biodiversity! My dog and I see violet green swallows and western bluebirds nesting in the lovely old snag, flocks of goldfinches and house finches eat seeds in the meadow, redtail hawks and an occasional peregrine falcon or great blue heron fly overhead. We come across deer with fawns, the elk with the massive crooked antler, Abert's squirrels, prairie dogs, rabbits, coyotes, and an occasional porcupine (too up close and personal for the inquisitive dog, I'm afraid). But it is the great variety of plants that intrigues me the most. After the lovely snows of this past winter, there were many crag lilies and hundreds of sego lilies, and the massive claret cup cactus had 49 flowers (tho none set fruit!). With the summer rains came iridescent blue dayflowers, an unbelievable riot of late-summer-fall wildflowers and fields of sunflowers and goldeneyes. Now the leaves are rust-colored and the lone bottle gentian has set a few pods.

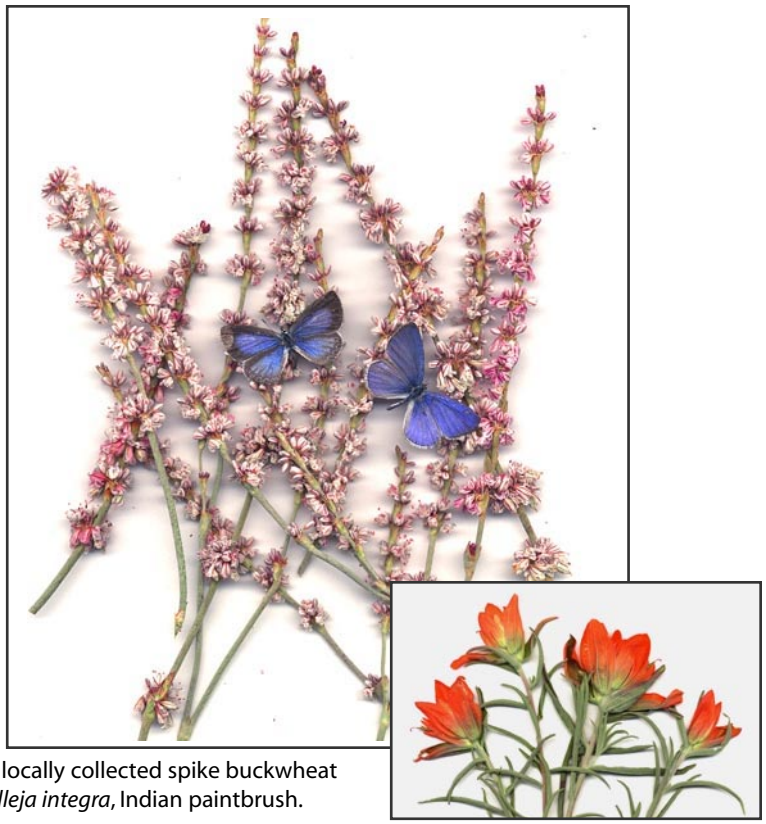
We have chosen in this issue of *The Plant Press* to highlight how some of our members are studying and enhancing the biodiversity that fosters resiliency in our native ecosystems. We hope you will find inspiration to explore ways you can work with us to promote knowledge, appreciation, conservation, and restoration of Arizona's native plants and their habitats, the mission of the Arizona Native Plant Society!

above *Penstemon strictus,* Rocky Mountain penstemon

The Diversity of Western Flowers *continued*

Penstemons (*Penstemon* spp., Scrophulariaceae) are readily recognized in the West: they are everywhere, from deserts to above treeline. It is a genus that is endemic to North America. Between 270 and 300 penstemon species have been recognized and 90% of them live in the West. In reality, there are an enormous number of varieties also known to penstemons, so they are even more diverse. Penstemons probably originated in the Rocky Mountains by about 1.6 million years ago, and then spread through the West and then through eastern North America. In the West, they colonize a variety of substrates including shales, clays, sands, salt beds and cinders.

Penstemon evolution has also been highly influenced by its pollinators. Approximately 80% of penstemons are purple or purplish, with fairly wide corollas or floral tubes, and they are pollinated by an array of bees and flies. Pollinators are paid well by penstemons for their services: each flower produces a lot of nectar and replenishes it within several hours. About about 15% of penstemons have red *and* narrow tubular flowers that exclude all pollinators except for hummingbirds. To please hummingbirds, these red penstemons produce a nectar that is more dilute, containing more water. At the height of the blooming season, side by side patches of purple penstemons and red penstemons are worlds apart. I saw this firsthand recently at the Flagstaff Arboretum, where a patch of Rocky Mountain penstemon was alive with many visiting bees and flies, while there were no pollinators visiting the neighboring patch of red scarlet bugler, though a few hummingbirds could be heard in the area and were probably waiting for us to leave! Hummingbirds are excellent at pollinating red penstemons, such as the classic scarlet bugler. They are really effective at pollinating this plant in terms of moving lots of pollen to and away from a plant and yet, because red



above, from left *Penstemon barbatus,* scarlet penstemon; locally collected spike buckwheat *(Eriogonum racemosum)* & Euphilotes butterflies; and *Castilleja integra*, Indian paintbrush.

penstemons are always derived from purple penstemons (never visa versa) and there are relatively few red penstemons, it is thought that penstemons that specialize on hummingbird pollination are evolutionary deadends; perhaps hummingbirds are too inconsistent ultimately as pollinators to enable such species to persist.

Buckwheats (*Eriogonum* spp., Polygonaceae) are also North American endemics. And, as with penstemons, most of buckwheat's 250 species occur in the West. There are over 50 buckwheat species in Arizona alone. Buckwheats may have originated during the Miocene (~5-20 million years ago), when climates were drying out and grasslands were expanding, though they diversified rapidly and to a great degree during the Pliocene and Pleistocene (~5million to 10,000 years ago) that followed. Most buckwheat species are drought tolerant, which has contributed to their success in the arid and semi-arid West. They occur in most habitats, from the Pacific shoreline to the shale barrens of the Appalachian Mountains and from below sea level to more than 13,000 feet. One species, *E. nummulare*, is even adapted to salt beds left by Pleistocene lakes, which are far saltier than the ocean. Most buckwheats are local endemics, that is, individual species have very small ranges. Steamboat buckwheat's (*E. ovalifolium* var. *williamsiae*) entire range encompasses 250 acres in thermal spring deposits in Nevada.

The small ranges of many buckwheats have led to some interesting interactions with the insects that are associated with them. The blue or buckwheat blues butterflies (*Eulophilotes* spp., Lyceanidae) that lay their eggs in buckwheat flowers must time their reproduction, egglaying and larval feeding to coincide with the blooming of buckwheats, a process which may last for only four to six weeks. Because different buckwheat species bloom at different times during the summer, it is thought that many of the blues that occur on just one buckwheat species have become isolated from other species because of their host plant's unique flowering time.

Indian paintbrush (*Castilleja* spp., Scrophulariaceae) is one of the loveliest western flowers. Nearly all of its ~ 250 species occur in North America, and most of those occur in the West. Indian paintbrush also occurs from deserts to above treeline. Polyploidy, or the addition of entire chromosome sets, is really common among Indian paintbrush and is a contributor to its large number of species and varieties. In the Intermountain West, small mountain ranges such as the Uinta Mountains in Utah, may have 4 to 9 *Castilleja* species, with each occupying different habitats and having different ploidy races. Even within species, such as *C. miniata*, there are at least 4 different polyploidy races. As with penstemons, many Indian paintbrush species are pollinated by hummingbirds.

Indian paintbrush's reproductive success is also influenced by the type of plant it lives near and is able to parasitize. Indian paintbrush is a hemi-parasite of other plants: while it produces chlorophyll and photosynthesizes and produces some of its own food, it also depends on the nutrients found

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above *Aquilegia chrysantha,* yellow columbine.

The Diversity of Western Flowers *continued*

in the roots of neighboring plants. Basically, an Indian paintbrush that is able to parasitize a nitrogen-fixing lupine will produce more flowers and seeds than one that parasitizes a grass, for instance. I must confess that I haven't seen many Indian paintbrush in close proximity to lupines.

Columbines (*Aquilegia* spp., Ranunculaceae) may hail from Asia, and the most primitive columbine is found in the Himalayas. Today the genus is found throughout the northern hemisphere. Most columbine species are interfertile, or able to breed across species lines, and so it is thought that they may have arisen as recently as the mid-Pliocene, some 3.5 million years ago. The wide distribution of columbines combined with the ability of most species to mate with one another represent an intriguing mystery in science.

Today there are 25 recognized columbine species in North America, and most occur in the West. In reality, there is an even greater diversity of columbines, since many species, such as the beautiful Colorado columbine (*A. coerulea*) or western columbine (*A. formosa*) are actually comprised of many varieties. Many of these groups and species also hybridize giving rise to still more variation. And more endemics, such as in hanging gardens in Glen Canyon, Utah, are always being found. Columbines occur throughout the diverse topography of western North America, from alpine habitats to desert springs.

Also contributing to diversity in columbines are their pollinators. Columbines are pollinated by an array of pollinators, depending on the color of the flower, how it hangs on a plant and how long its nectar spur is. Yellow columbine is one of the longest-spurred columbine in Arizona and New Mexico (reaching 1.6 inches or more), and its upright flowers are commonly pollinated by hawkmoths with equally long tongues. The lovely red and yellow colored western columbine has much shorter spurs (0.6-0.8 inches). These traits, combined with the fact that it has nodding flowers, result in its being readily pollinated by hummingbirds. Flowers with short spurs and light colored flowers, such as the alcove columbine (*A. micrantha*), are pollinated to a large degree by bumble-bees. Relationships with particular pollinators have led to a greater diversity of columbines.

This is just a small sampling of diverse western flowers. Other groups which have their greatest diversity in western North America include vetches (*Astragalus* spp.) and various composites. How lucky we are to see such diversity!

above A Tumamoc globeberry plant in Saguaro National Park.

Revisiting the Tumamoc Globeberry

by Frank W. Reichenbacher[1] Photos courtesy the author.

Tumamoc globeberry (*Tumamoca macdougalii* Rose) is a delicate dioecious or monoecious vine found in and on the sheltering canopies of desert shrubs and trees in south-central Arizona, western and southern Sonora, and northern Sinaloa.

Partly as a result of my work under contracts from the U.S. Fish & Wildlife Service and the U.S. Bureau of Reclamation (BOR) in preparation for the Central Arizona Project (CAP) this fascinating cucumber relative was listed as an endangered species in 1986. Subsequent large scale surveys throughout the range of Tumamoc globeberry in Arizona and Sonora also related to the CAP and also mostly done by me and my employees, found it to be widespread throughout available habitat in western Sonora. So by 1993, the Tumamoc globeberry was removed from the endangered species list.

In early 2007 I was told that floods in Sabino Canyon in 2006 may have impacted a population of Tumamoc globeberry and, at the same time, I was told it was becoming very difficult to locate Tumamoc globeberry plants at the type locality for the genus and species on Tumamoc Hill.

In August and September 2007 I decided to revisit both sites to try to relocate Tumamoc globeberry plants. After visiting the Sabino Canyon and Tumamoc Hill sites, we became concerned and decided to also visit three additional sites that had been purchased by the U.S. Bureau of Reclamation (BOR) in the early 1990s and enclosed by javelina-proof fencing in order to preserve the Tumamoc globeberry. In traveling to the BOR sites we discovered a new (to me) population of Tumamoc globeberry in Saguaro National Park.

August 2, 2008, we came back to the Sabino Canyon site to do a quick population check-up prior to submitting this article.

From approximately 1983 through 1995, I and others conducted dozens of surveys and studies for and about

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Revisiting the Tumamoc Globeberry *continued*

Tumamoc globeberry with widely varying purposes and levels of documentation and detail. The resources available to me to conduct the 2007 revisits were likewise variable. For the Sabino Canyon population, I had a few photographs, permanently tagged plants and nurse plants, and a highly detailed map showing the location of individual plants. Luckily we were able to relocate all of the aluminum tags with a hobbyist's metal detector. My records of the Tumamoc Hill population included only computer files that had our crudely surveyed landmarks, nurse plants, and lists of Tumamoc globeberry found. For the three BOR preserves in Avra Valley we had only the nurse plants of one or more Tumamoca identified on aerial photos and a list of the plants found there. Most of the original datasheets, maps, aerial photographs, and reports were not available.

Tumamoc globeberry is always found in the shade of and among the canopies of other shrubs and trees. These so-called "nurse plants" provide habitat for seed germination, shelter for seedlings and juveniles, and support for the display of flowers to potential pollinators and presentation of fruits to potential seed dispersers (Figure 1). Although I did not have detailed location data for some of the sites, at the very least I expected we would be able to relocate the nurse plant that had protected one or more Tumamoc globeberry plants documented in past surveys and probably find new individuals.

In the presentation of results in Table 1, I tried to determine how many plants should have been at the locations specifically searched in 2007. In most cases this number is based on more than one year of surveys. I visited the CAP Aqueduct site, for example, every year from 1983 to 1991, and then in 1993 and 1995. I also visited the Picture Rocks site on numerous occasions in the late 1980s in an effort to photographically document the Tumamoc globeberry life history. I placed several markers in the ground next to my study plants during that period which were still visible in 2007.

figure 1 Close-up of fruit.

As shown in Table 1, the Tumamoc globeberry populations at the Sabino Canyon, Tumamoc Hill, CAP Right-of Way, and Mile Wide/Sandario sites have experienced severe population declines. Except for some flooding of the Sabino Canyon Tumamoc globeberry site in 2006 (which does not appear to have directly impacted any of the Tumamoc globeberry plants) and except for the abundant herbaceous vegetation encouraged by the equally abundant summer rains, the physical conditions at all of the sites were very much as I recalled.

Our August 2, 2008 revisit of the Sabino Canyon population was very important. One of the juveniles found in 2007 was missing, but we discovered a new seedling, so the numbers are the same, but the population dynamics that seem to be typical for the species seem to still apply. New seedlings come up but most of them fail to establish.

Only at the Picture Rocks Road site was Tumamoc Globeberry found in large numbers; approximately twice as many plants were found as had been documented in the 1984 surveys. As with all of the other sites we revisited, the Picture Rocks site appeared to have been untouched since last surveyed seventeen years ago. All of the other populations appeared to have experienced drastic declines.

On the way to Picture Rocks Road site, the crew happened on a new Tumamoc globeberry population (new to me anyway) consisting of at least 20-30 individuals, seedlings, juveniles, and adults in Saguaro National Park.

TABLE 1. Summary of the results of the 2007 Surveys of Tumamoc Globeberry. "Last Survey Date" represents the latest date of surveys with data available to me. "Expected Population" represents my best estimate of the number of Tumamoc globeberry plants which should have been found in the 2007 surveys.

Site Name	Last Survey Date	Expected Population	Results 2007	Results 2008
Sabino Canyon	9/1995	~40	5	5
Tumamoc Hill North*	9/10/1984	~67	15	-
Tumamoc Hill South	9/10-11/1984	33	3	-
Picture Rocks Bureau of Reclamation	10/8/1990	64	120	-
Mile Wide Sandario	10/10/1990	14	4	-
CAP Aqueduct	8/1990	177	6	-

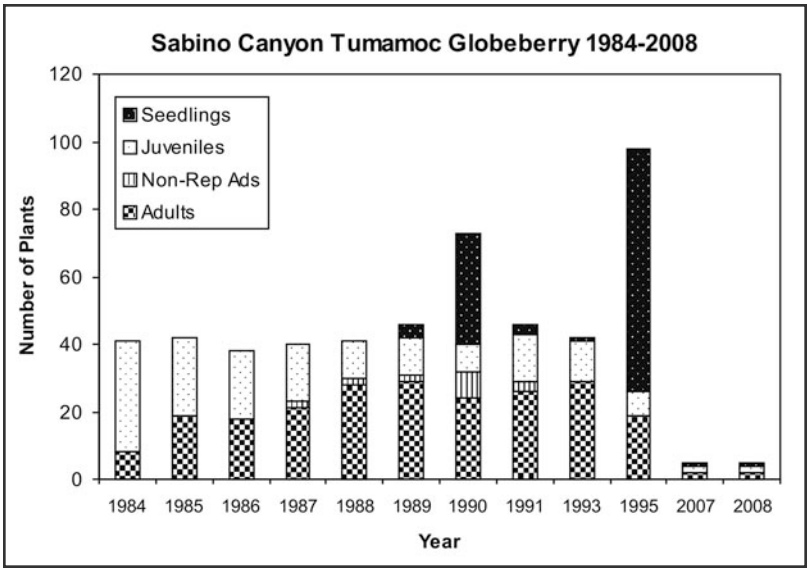

figure 2 Sabino Canyon Tumamoc Globeberry, 1984–2008

No previous data existed for this site, but in just a few minutes of searching, we had no trouble locating more plants than we had located at Sabino Canyon, Tumamoc Hill, the CAP Aqueduct, and Mile Wide Sandario sites together.

At Sabino Canyon, the two Tumamoc Hill sites, CAP Aqueduct, and Mile Wide Sandario we attempted to relocate a total of 331 Tumamoc globeberry plants. We actually found 33 plants, or 10%. It is possible that we actually relocated one single individual, but all, or nearly all, of the remaining plants we found grew since the previous survey. This is not what was expected. During the 11 years of monitoring the Sabino Canyon plants and other populations of Tumamoc globeberry which I and others monitored in eastern Pima County, it was clear that most of the largest adults persisted for the whole period of the study. Crops of seedlings that were produced during good summer rainfall years tended not to persist and had little effect on the total size of the population. There was no reason to expect that this pattern would not continue.

I think that the most likely factors in the remarkable Tumamoc globeberry population decline documented here were javelina predation, lack of summer precipitation, and increasingly severe winter freezes.

Javelina predation might have caused the decline, but it is very difficult to reach a firm conclusion on this with the prior information available. In addition, we did not see any evidence of recent javelina predation during the 2007 or 2008 surveys. The three Tumamoc globeberry preserves — CAP Aqueduct, Picture Rocks Road, and Mile Wide Sandario — had all been fenced with supposedly javelina-proof fencing. We did not attempt to verify the integrity of the fencing at any of the preserve sites in 2007.

Summer precipitation has actually increased slightly in the Tucson area since the early 1990s. In addition, 2006, 2007, 2008 were excellent summer rainfall years. The plants we found in 2007 and 2008 were all green and healthy and, when we found Tumamoc globeberry plants, we found seedlings and juveniles. We should rule out the effects of changes in summer precipitation on Tumamoc globeberry.

The effect of winter freezes is the only factor that I find may account for the decline. The Tumamoc globeberry sites that experienced declines are bottomland sites (Sabino Canyon, Tumamoc Hill, and CAP canal) which receive cold air drainage, while the two sites which still support good numbers of Tumamoc globeberry (Saguaro National Monument and Picture Rocks Road BOR preserve) are on bajadas which should be warmer even during cold periods. We ideally need accurate temperature data from the heart of some of the populations that experienced declines to be able to reach a firm conclusion. As far as I can determine, however, there are no such data.

Future Work

Tumamoc globeberry was dropped from the list of endangered species primarily on the basis of its widespread distribution in extremely remote deserts of western Sonora, Mexico. Populations in eastern Pima County, central and southern Sonora, and northern Sinaloa, were and still are threatened by development and habitat modification on many levels. If Tumamoc globeberry is also declining in its western Sonora strongholds, this would be very alarming and would indicate a need to put the Tumamoc globeberry back on the list of endangered species.

It is imperative that additional field surveys of Tumamoc globeberry be carried out elsewhere in Pima County. But it is even more important to conduct surveys in Sonora, Mexico, where the species was found to be widespread in our field surveys from the late 1980's to the mid-1990's.

Literature Cited

U.S. Fish and Wildlife Service. 1986. Endangered and threatened wildlife and plants; determination of endangered status for Tumamoca macdougalii (Tumamoc globeberry). Federal Register Vol. 51, No. 118, pp. 15911-15918.

U.S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants; final rule to delist the plant Tumamoca macdougalii. Federal Register Vol. 58, No. 116, pp. 33562-33565.

Acknowledgements: I would like to thank some of the many people who assisted in this study. Joshua D. Taiz, Biologist at the Coronado National Forest, Santa Catalina Ranger District, Dave Bertelsen, an enthusiastic and extremely knowledgeable "citizen" botanist, and Jim Verrier, of Desert Survivors Plant Nursery, both accompanied me on all of the revisits. Thomas R. Van Devender, of the Arizona-Sonora Desert Museum, first suggested the need for a check-up on the status of Tumamoc globeberry. Sue Rutman, Biologist, Organ Pipe Cactus National Monument (ORPI), had some good ideas for additional information and contacts and she did a quick check on the Tumamoc globeberry at ORPI (they seem fine).

CONSERVATION COMMITTEE UPDATE

Busy, as Usual!

by Greta Anderson, Conservation Chair **conservation@aznps.org** *and Barbara G. Phillips,President*

The Conservation Committee has been busy as usual, spreading the word about the importance of native plants and the threats posed by non-native invasive species. Much work has been focused in southern Arizona, but actions around the state are occurring also.

Southern Arizona

A major success of this past spring was the "Wild in the City" yard tour, which raised funds for our committee and educated 150 attendees about the beauty and function of native plants. There were six gardens on the tour and each yard highlighted an aspect of urban wildlife habitat design and sustainability, including water harvesting. We had a lot of fun and learned so much. We've got some good ideas for next year or for helping other chapters and groups host a similar event. Special thanks to each of the yard owners for making it a success!

Another exciting activity of last spring was the production of our "Native Plants for Desert Tortoise" brochure. We unveiled this new brochure at the yard tour and at a tortoise "Adopt-a-thon" held at the AZ Game and Fish Department office in Tucson. (Last year, we completed a tortoise garden at the same location.) The point of the brochure is to educate tortoise owners and adopters about native plant gardening for tortoise food and habitat and, it turns out, there is quite a demand for this information: we've already printed and distributed several thousand. The brochure is now available on our website: **www.aznps.org/conservation.html** and is available for self-printing by organizations or individuals.

We continue to engage in buffelgrass eradication education and actions, including participating in the local and state planning for invasive species removals. In the past six months, we've helped to remove buffelgrass from Sabino Canyon and Tucson Mountain Park, and we've also given presentations on "Grow Native: Don't Plant a Pest," to interested civic organizations. We are also developing a video that can be used online, in classrooms, or at outreach events. Check back soon for details about that project.

In addition to encouraging non-native plant removal, we have been trying to facilitate native plantings by giving away native plant seed at events. This past spring we gave away desert senna and devil's claw seed packets, and we have been collecting more varieties of seeds to spread around in the future. We have also continued our reward program where we provide gift certificates for native plants from the Desert Survivors Nursery to super-star volunteers and worthy buffelgrass-pullers.

Northern Arizona:

Members of the Flagstaff Chapter have been very active in plant conservation activities during the spring and summer of 2008, too. In July we held the 2008 Native Plant Garden Competition in conjunction with the City of Flagstaff Xeriscape Contest. Eight native plant gardens were entered in the non-professional category, three in the professional,

continued

This exquisite card was created for AZNPS by a Prescott artist, Carolyn Schmitz, and donated for our use. Decorated with desert Christmas cactus, Snake skin, prickly pear cactus fiber, devil's claw, yucca blooms, rattlesnake rattles, and more, these cards are a one-of-a-kind holiday greeting.

Special 2008 Deal for AZNPS members!

The cards come 10 to a packet with envelopes for just $10 (plus postage). Sales from the cards directly benefit the work of the Conservation Committee.

Please send your order to AZNPS, POB 41206, Tucson AZ 85717 with checks payable to the Conservation Committee of AZNPS. We'll ship your cards right out to you.

Contact conservation@aznps.org with any questions.

and one was given a special judges' award for use of native plants and volunteer service. Similar to last year, over a hundred people enjoyed learning about how to use native plants and talking with the gardeners during the garden tour on August 24. We thank everyone who helped organize, judge, and participated in this highly successful event.

Under the direction of AZNPS member, Scott Harger, the San Francisco Peaks Weed Management Area has held informational/coordination meetings which several northern Arizona AZNPS members attended. We captured and dispersed biocontrol insects for diffuse knapweed and Dalmatian toadflax. (Photos)

AZNPS members have also been actively participating in the Northern Arizona Native Seed Alliance (NANSA). A highlight was the late July tour of the Los Lunas Plant Materials Center (National Resource Conservation Service) to learn about the facilities and how NANSA can interact with it in the future as we work to develop local native seed sources and resources in northern Arizona. (See **www.emaprogram.com/emaweb/ ema/site/nansa.asp** website for more information on NANSA.)

AZNPS members are also very actively volunteering with the Museum of Northern Arizona (MNA) and the Arboretum at Flagstaff in their native seed-collecting events, and other projects involving native plants such as the National Seed Lab training put on by the Forest Service at the Arboretum at Flagstaff in late August. MNA is preparing an extensive living roof, planted with native grasses and wildflowers, and designed to provide a high degree of insulation for the structure and to slow run-off from the building onto the surrounding landscape for their new collections building. (see http://www.musnaz.org/webcam.html for videocam of this). AZNPS members have been planting grass plugs and seeds in thousands of coconut fiber baskets to be placed on this roof in November.

See also the article by Kate Watters (this issue of *The Plant Press*) regarding PAPAZ training and the "Budding Botanist" volunteer program that was initiated in Flagstaff by several AZNPS members this Spring.

Many thanks to all who work on conservation efforts throughout the state!

EDUCATION & OUTREACH COMMITTEE UPDATE

North Rim PAPAZ (Plant Atlas Program of Arizona) Adventure *by Wendy Hodgson, Education & Outreach Committee Chair*

Incredible lightning, thunder, and rain could not dampen the spirits of a small group of Grand Canyon Field Institute participants helping Glenn Rink, Barb Phillips and me document and collect plants from often cryptic springs and seep holes on the North Rim of Grand Canyon National Park and Kaibab National Forest. This trip was part of a larger study orchestrated and put into action by Glenn to further our understanding of the Rim's flora, which is a part of a larger effort to document the flora of Arizona, the goal of PAPAZ, the Plant Atlas Program of Arizona. Jeri Grandy (Grand Canyon Association board member), Don Witter, and Bill and Susan Ahearn joined Barb, Glenn and me for five fun-filled days of searching for plants at sites selected by Glenn. Some so-called seeps were a figment of one's imagination, while others, including a massive sinkhole, amazed us with their size and diversity of plants. Thrashing through vegetation down side canyons such as Big Spring Canyon/upper reaches of Shinumo Creek rewarded us with orchids galore, including the often evasive Bog orchid (*Platanthera* spp.). By clambering up forested slopes we were delighted to find Rattlesnake-plantain (*Goodyera* sp.), Coralroot (*Corallorhiza* sp.) and the beautiful Fairyslipper orchid (*Calypso bulbosa*). Such slopes also produced a ménage of wintergreen species in the Pyrolaceae including pipsissewa (*Chimaphila umbellata*), sidebells (*Orthilia secunda*), green-flower wintergreen (*Pyrola chlorantha*), the beautiful white-veined wintergreen (*P. picta*) and snowline wintergreen (*P. minor*).

This experience again illustrates how people who are not professionally-trained botanists but have desire, ability, and enthusiasm can contribute greatly towards our ability to understand and document the diversity of this amazing part of the country. Future opportunities will continue to be provided for those who would like to participate in these endeavors. Kate Watters and staff have put together a wonderful site on the Grand Canyon Trust website called the "Budding Botanist Program," which highlights and describes such opportunities (**www.gcvolunteers.org/documents/BuddingBotanistPerennialVolunteerProject.pdf**). We expect this program to continue to grow and look forward to seeing more of you out in the field having fun and contributing towards this much needed and rewarding cause.

Endemic Plants of Arizona: A Working List

by Todd Ontl[1] and Andrew Salywon[2]

By all accounts, Arizona is a botanically rich state. Estimations of total numbers of vascular plant species are likely around 3500, placing the Grand Canyon state third in the U.S. for total plant diversity (Stein 2002). This richness of species is a result of the many geographical and environmental factors that make Arizona unique. Indeed, as many southwestern botanists know, the array of flora found in our state is just as unique as the landscape itself is. But a thorough understanding of just how unique the flora of Arizona is has been lacking. Information on plant species that are endemic, or unique to Arizona, would greatly increase our understanding of the ecology and evolution of our exceptional flora, and is vital for its conservation. For this reason, we have begun this project at the Desert Botanical Gardens to investigate species endemic to Arizona: which ones they are, and what habitats they occupy.

The richness of Arizona's flora is due in part to the diversity of habitats found within our state. The northern portion of the state is located in the Colorado Plateau Geologic Province, while the remainder falls within the Basin and Range Geologic Province. The elevational gradient that results is quite large: elevations range from over 12,000 feet in the San Francisco Peaks north of Flagstaff to 70 feet at the Colorado River near Yuma. This gradient, combined with the latitudinal differences from north to south, results in a wide variety of environmental conditions on a regional scale. Environmental conditions are further diversified by localized variation as well. In addition to differences in slope, aspect, and soil depth, differences in soils derived from various parent materials such as volcanic rock, lacustrine deposits, or shale result in a wide variety of localized soil types. These unique soil types often have properties that make them distinctive habitats such as markedly high or low mineral concentrations which have very marked influences on plant species composition.

Arizona lies at a crossroads of floristic regions that has had an influence on the diversity of the flora of our region. The Great Basin Floristic Province dominates the northern portion of the state on the Colorado Plateau Region, while the Four Corners Region falls within the Rocky Mountain Floristic Province. The rest of Arizona is within the Sonoran Floristic Province, and is the only state which contains all three subdivisions found within the US: the Mojavean, Sonoran, and Chihuahuan Sub-provinces. The Californian Floristic Province is found to the west of Arizona as well and has likely been a force in the development of certain vegetation types.

The combined interactions of these abiotic and biotic factors result in the modern vegetation patterns in Arizona. On a regional scale there are generally considered to be between 13 and 14 different community types in Arizona, ranging from the multiple types of desert scrub, to grasslands, chaparral, different types of woodlands and forest types, riparian communities, all the way up to alpine tundra. On a regional scale there is a fairly robust correlation between plant diversity and endemism; therefore, one would expect high rates of endemism in the regional flora. However, endemics are not distributed equally across the landscape. An understanding of the causes of endemism can lead to predictions of areas that would be expected to show high rates or total numbers of endemic species.

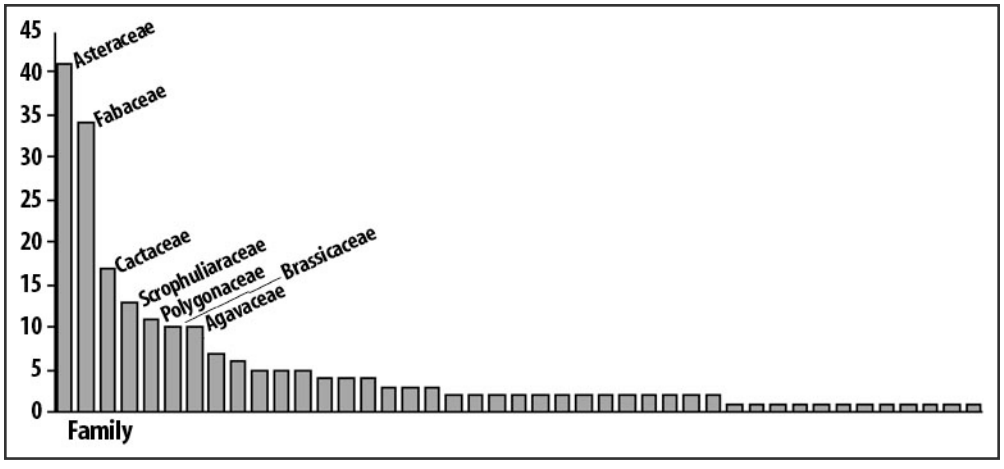

figure 1

Why some species are widely distributed whereas others are restricted is a question plant ecologists are still trying to figure out answers to. However, there are some general evolutionary processes that result in limited distributions in plant species and endemism. *Neoendemics* are species that have recently evolved due to recent changes in the habitat or niche space available. These species are sometimes thought to occupy

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ranges smaller than their environmental tolerances or competitive abilities might allow, but have had limited opportunities to expand their range due to time or dispersal ability. *Edaphic endemics* are species that are adapted to survive in specific soil conditions where competition from other species is reduced, usually due to chemical composition, such as limiting or excessive mineral concentrations for which the normally dominant species do not have as high a tolerance. Arizona has a couple of great examples of this, one of which is *Astragalus newberryii* var. *aquarii*, which is restricted to a very narrow range near the border of Mohave and Yavapai counties in an area where soils are derived from lakebed deposits. *Paleoendemics* are relict species the usually had a much wider distribution, but whose habitat has decreased over geologic time periods with the changing environment. *Simmondsia chinensis* is thought to be a relict species restricted to southern Arizona, S. California, and northern Baja Mexico.

In *Flora of Arizona*, Kearney and Peebles (1951, 1960) projected that nearly 5 percent of the flora, or 164 species, are endemic to Arizona. According to their estimations, the southern portion of the state contained the most endemics (74). 46 species were believed to be confined to the northern portion of the state, with 28 endemics in the central region. The authors identified 16 endemic species that had a wide distribution within Arizona. It is unknown which species the authors had identified as Arizona endemics, so an intensive review of the literature as well as database searches of herbarium collections in Arizona and neighboring states on Arizona's flora was done in order to identify endemics. Information included distribution and habitat descriptions. Consideration was also given to "near endemics": species found within Arizona as well within approximately 50 miles of the state line in bordering states and Mexico.

The results of this search are preliminary lists of endemics and near endemics, many of them well documented, but certainly including many species with little published information on habitat descriptions or conservation status. The list contains a total of 223 potential endemic species across 43 families (Figure 1), much higher than Kearney and Peebles' estimate. The increase is likely a result of the discovery of many new species, subspecies, and varieties due to further exploration of Arizona's diverse habitats as well as advances, such as cellular and molecular techniques. The families with the highest numbers of endemics include the Asteraceae (41), Fabaceae (34), Cactaceae (17). 57 near endemic species were identified as well.

The patterns of distribution of endemic species certainly show striking differences to Kearney and Peebles distribution estimates. Occurrences of endemic species at the county level (Figure 2) show counties in the northern portion of the state have the most occurrences of endemics, with Coconino county leading the state with over half (55.6%) of Arizona's

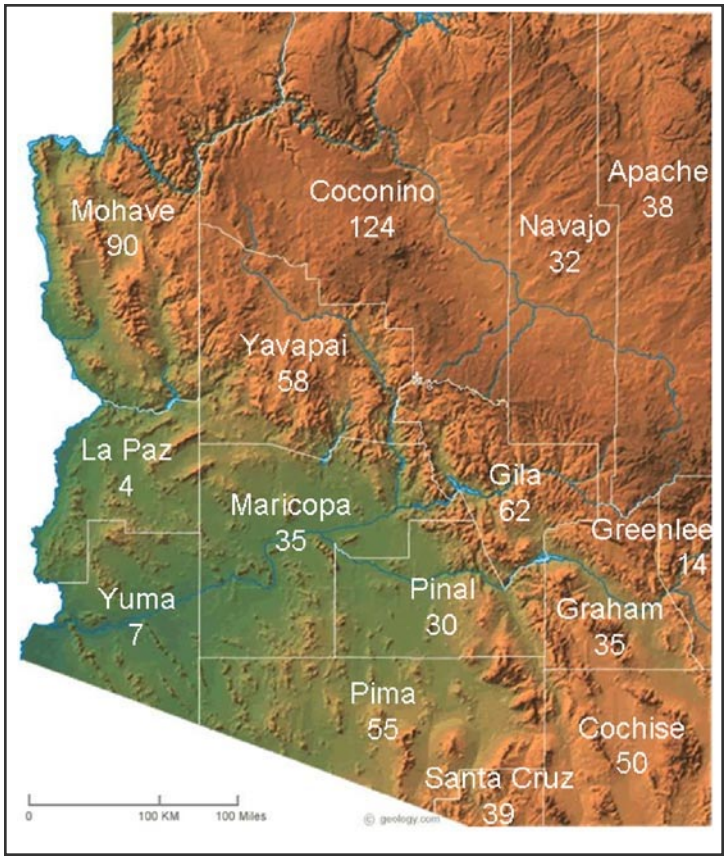

figure 2

endemic species occurring within the county. The second highest numbers of endemic species occurrences were in the central counties of the state containing the Apache Highlands Ecoregion including Gila County (62) and Yavapai County (58). The southern counties were close behind, with Pima County with 55 occurrences and 50 recorded occurrences in Cochise County. (These numbers are raw data and do not reflect standardization based on area of county.)

This list is a working list and will be updated as new endemic species are described. Information on taxonomic status can change, and distribution data for many species is incomplete or inaccurate. The list is in its preliminary stages and will need to be further checked for accuracy prior to publication. However, we will continue to sort through the data available to "fine tune" this list and plan to eventually make it available to the scientific and botanical community in order to help in the conservation, study, and appreciation of our unique and amazing flora. For more information, please contact Andrew Salywon.

Literature Cited

Kearney, T. H. & R. H. Peebles. 1951. *Arizona Flora.* University of California Press, Berkeley, CA.

Stein, B. A.. 2002. *States of the Union: Ranking America's Biodiversity*. Arlington, Virginia: NatureServe.

SPOTLIGHT ON A NATIVE PLANT

Sunset Crater Beardtongue

by Judy Springer, Ecological Restoration Institute, Northern Arizona University **Judith.Springer@nau.edu**

Sunset Crater beardtongue (*Penstemon clutei* A. Nelson) is an endemic species of the cinder hills area northeast of Flagstaff. The type specimen was collected by Willard Clute in July 1923 north of the San Francisco Peaks in "lava sand," and was described and named by Aven Nelson at the University of Wyoming. Growing to about 20-30 in. (50-75 cm) in height, the plant has bluish-green leaves with sharp serrations on the margins, and gradually inflated, deep pink corollas. It flowers from June through September.

Penstemon clutei grows only in areas with fairly recent volcanic activity, primarily within Sunset Crater National Monument and the surrounding vicinity, at an elevation of approximately 7000 ft. (2135 m). It is typically found in open ponderosa pine forests and pinyon-juniper woodlands in areas of sparse understory vegetation (it is thought to be a poor competitor) and tends to grow on fairly coarse and dry, cindery soils that lie over a silty moisture-holding layer. Pollinators include both bees and hummingbirds.

It was previously thought that *P. clutei* required fire to maintain itself, but recent research seems to indicate that almost any disturbance, so long as it is not too severe, will promote colonization of this species (Fulé et al. 2001). It is commonly found growing near recent pine snags, old logging slash, road cuts, and scars from wildfires. It also emerged prolifically in the aftermath of a 1992 tornado (Crisp 1996). Current threats include off-road vehicle activity, development and browsing by herbivores.

above *Penstemon clutei* courtesy Mark Daniels, NAU Ecological Restoration Institute

P. clutei is a showy species and makes a fine garden specimen for almost any climate. Seeds cannot be collected in the wild without a permit, but are available from several nurseries in Arizona and also through on-line sources. Despite occurring only on cindery soils in its native habitat, the plant will grow on almost any type of well-drained soil in full sun, and is highly drought tolerant. Plants can grow to a large size with numerous flowering stems on rich soil; however, the life of the plant may be shortened. It is not known how long it lives in the wild, but it can survive for five years or more in cultivation and will self-sow if conditions are favorable.

Literature Cited

Crisp, D. 1996. Monitoring of *Penstemon clutei* A. Nels. on Tornado Salvage. Pp. 243-246. *In:* Maschinski, J., H. D. Hammond, and L. Holter, tech. eds. Southwest rare and endangered plants: Proceedings of the Second Conference; Sept. 11-14, 1995; Flagstaff, AZ. Proceedings RM-GTR-283. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimental Station. 328 pp.

Fulé, P. Z., J. D. Springer, D. W. Huffman, and W. W. Covington. 2001. Response of a rare endemic, *Penstemon clutei*, to burning and reduced belowground competition. Pp. 139-152 *In*: Maschinski, J. and L. Holter, tech. eds. Southwest rare and endangered plants: Proceedings of the Third Conference; Sept. 25-28, 2000; Flagstaff, AZ. Proceedings RMRS-P-23. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 250 pp.

Hidden within our Botanical Richness, a Treasure Trove of Fungal Endophytes

by A. Elizabeth Arnold [1] *Photos courtesy the author.*

To anyone with an eye for diversity, Arizona's botanical richness is nothing short of inspiring. Unbeknownst to many botanists, however, is the fact that Arizona's plants harbor upon and within their tissues an even greater richness of fungi. Some fungi associate with plant roots, forming mycorrhizae that increase nutrient uptake, enhance plant water relations, and in some cases protect host plants from disease. Others grow with algae or cyanobacteria to form lichens that occur on exposed surfaces such as bark or, under conditions of high humidity, leaves. Still more fungi can be found as spores or hyphae on the exterior surfaces of plant tissues, as single cells in the nectar of flowers, as agents of decay when plant tissues die, or as pathogens that cause disease in leaves, stems, roots and reproductive organs.

In addition to these relatively well-recognized fungi, yet another group lives in close association with plants and plays an array of ecological roles that, for plants in Arizona, remain largely unexplored. These are **fungal endophytes** — fungi that live within plant tissues such as stems and leaves without inducing symptoms of disease.

Recent studies indicate that Arizona's botanical richness corresponds to a tremendous diversity of fungal endophytes, few of which have been studied in any detail. Endophytes are closely related to many pathogens that infect the same tissues, but probably have evolved into non-virulent inhabitants of plants multiple times across the fungal tree of life. In natural and human-made ecosystems they can protect plants against disease and herbivory, enhance plant growth under challenging abiotic conditions, and provide the raw materials for a remarkable number of applications in biological control, biofuels, and pharmaceutical bioprospecting. To date, however, only a vanishing minority of Arizona's plants have been screened for their endophytic fungi.

The placement of our state at the confluence of several biogeographic and botanical provinces makes Arizona an exceptionally exciting place to study the diversity, ecology, and potential applications of fungal endophytes. Here, I briefly introduce these ubiquitous symbionts of Arizona's plants.

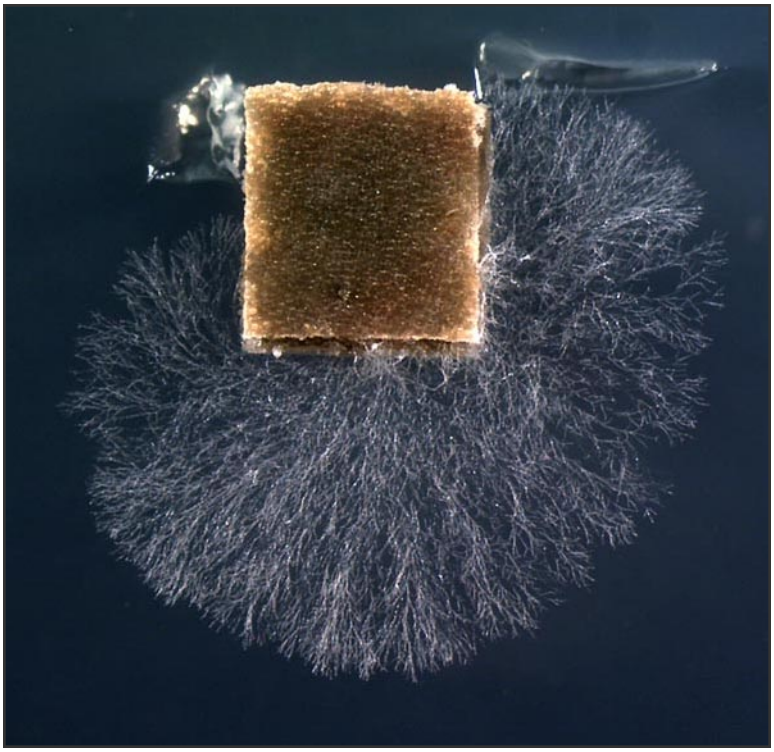

figure 1 Endophytic fungus emerging from a surface-sterilized leaf piece (ca. 0.07x 0.07 inches) on 2% malt extract agar.

Introduction to fungal endophytes

When first introduced in 1866, "endophyte" was used broadly to refer to any organism found within tissues of living plants. Subsequent re-definitions led to confusion regarding the meaning of the term, but modern mycologists generally agree that endophytes are *organisms that colonize internal plant tissues without causing apparent harm to their host.*

Research in my group (http://www.endophytes.org) focuses on foliar fungal endophytes – those endophytes that occur inside healthy leaves and other photosynthetic organs. The vast majority of foliar endophytes (hereafter, endophytes) are members of the Ascomycota, the most diverse phylum of fungi.

Endophytes have been recovered from plants in hot deserts, Arctic tundra, mangroves, temperate and tropical forests, grasslands and savannas, and croplands. They are known from mosses and other nonvascular plants, ferns and other seedless plants, conifers, and flowering plants. Every plant species examined to date is host to at least one endophytic fungus, and many plant species associate with hundreds to thousands of endophyte species across their geographic ranges. In Arizona, we have recovered endophytes from hosts as geographically, phylogenetically, and ecologically divergent as mosses along creeks in the Chiricahuas, liverworts from the Tucson Mountains, ferns growing among rocks in oak/juniper woodlands below the Mogollon Rim, ponderosa

continued next page

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A Treasure Trove of Fungal Endophytes *continued*

pines at the top of the Chuska Mountains, cultivated cycads on the University of Arizona campus, cypresses near burned areas in the Santa Catalinas, and medicinal annuals in the central Navajo Nation — just to name a few. Other researchers have recovered endophytes from a variety of cacti, oaks, and grasses throughout the state.

Because endophytes live within healthy tissue, their presence is unapparent: they manifest no evident, external symptoms or reproductive structures on plant tissues. The tiny, threadlike growth of these fungi (i.e., hyphae) can only rarely be visualized in leaf tissues without chemical fixation — and when observed *in planta* they lack sufficient characters to be identified. Therefore, endophytes typically are studied by culturing: plant tissues are surface-sterilized using chemical agents (*e.g.*, ethanol, sodium hypochlorite) and small pieces are placed under sterile conditions on a nutrient medium. Over time, fungi grow from these leaf pieces into the surrounding medium, and can be isolated in pure culture (Fig. 1).

Typical media include malt extract agar, corn meal agar, potato dextrose agar, and other nutrient sources derived from plants. In some cases antibiotics or other chemical agents are added to restrict bacterial growth and slow the growth of 'weedy' fungi. Often, the fungi that are less 'weedy' – that is, less cosmopolitan, and more slowly growing – are more interesting for drug discovery and other applications.

The proportion of tissue pieces yielding endophytes in culture is used as a measure of infection frequency, which can be compared among hosts and sites. Because the endophytes found in most plants are horizontally transmitted (i.e., spread contagiously among plants, rather than passed from maternal plants to offspring), older leaves tend to bear more endophytes than younger leaves. Infection frequencies generally follow a broad latitudinal gradient, peaking in moist to wet tropical forests and reaching their lowest in boreal and tundra ecosystems. At smaller scales, though, local factors such as humidity, exposure to UV, and seasonality all shape infection frequencies, with plants in wetter, warmer, and more sheltered places more frequently harboring higher abundances of endophytes.

Once in pure culture, endophytes are examined for reproductive structures such as sexual or asexual spores. However, most endophytes do not readily sporulate in culture, so they lack the characteristics needed to identify them. Accordingly, endophytes often are grouped to "morphotypes" based on whole-colony or vegetative characteristics, and/or are identified using DNA sequence data. Molecular approaches are also being used to highlight the existence of unculturable fungi, which can be sequenced directly from plant tissues.

Following isolation (Fig. 2), endophytes can be stored as in sterile water and archived in a culture collection. Our laboratory, in conjunction with the Robert L. Gilbertson Mycological Herbarium (part of ARIZ), is developing the needed infrastructure to maintain these important voucher collections. Once safely stored and catalogued, these living cultures – which often can be maintained at room temperature – can be revived for further study or used for DNA sequencing, providing an exceptionally useful resource for future work.

To date, my research group has collected nearly 14,000 cultures of endophytic fungi, of which >4000 come from plants in Arizona.

Distribution and diversity of endophytes

One of the most compelling features of fungal endophytes is their exceptional diversity. This is true both at a global scale, where more than 1 million endophyte species are thought to exist, and at the scale of individual leaves, plants, and locations. Although we do not yet have a definitive understanding of the number of endophytes associated with a single plant or single species – nor can we reliably estimate the number of endophyte species present in Arizona – we now have an accumulation of studies suggesting that their diversity in our state is immense.

For example, to date we have identified 65 species of endophytes among the first 92 cultures we have obtained from *Cupressus arizonica* (Arizona cypress). These fungi, recovered from foliage, are distinct from all fungi recovered previously from twigs or roots of *C. arizonica.* A similar sampling effort that recovered 127 cultures from *Juniperus deppeana* (alligator juniper) has yielded roughly 90 species. In each case, samples were collected from three sites (*e.g.,* the Chiricahua Mountains, Mt. Lemmon, and near Prescott, AZ for *J. deppeana*), and in each case less than 5% of species were found in more than one sampling locality.

Further studies with other hosts in these sites reveal that oaks and pines have similarly diverse endophytes. Some of these endophytes are host-specific, but many are shared among even distantly related hosts. However, endophytes that are common in one host species are often vanishingly rare in others. Moreover, the fungal families we find most frequently in healthy foliage of the cypresses and junipers are distinct from those found in co-occurring oaks and pines — and those endophytes, in turn, differ from those most commonly found in mosses, liverworts, ferns, grasses, and flowering plants such as cacti in our study sites.

Thus far, our surveys indicate that geographic locality matters in terms of species diversity of endophytes, and host taxonomy and locality underlie the composition of

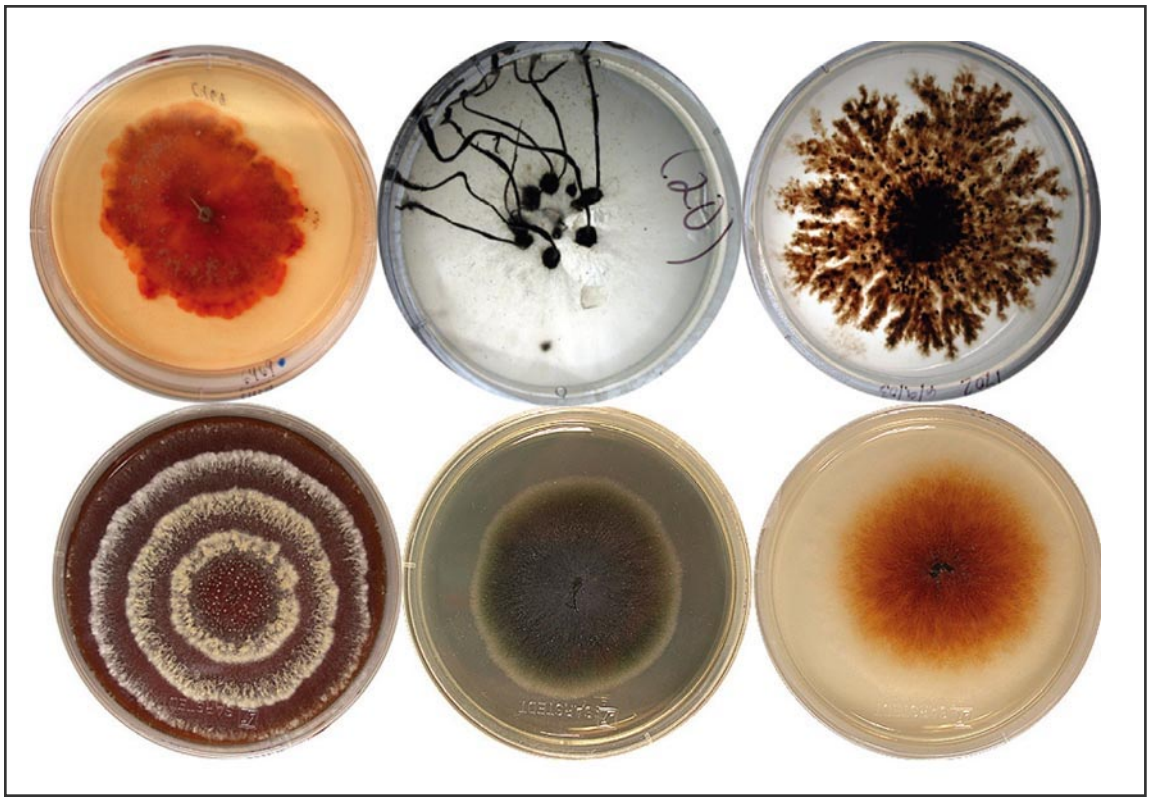


figure 2 Array of endophytic fungi in culture on 2% malt extract agar.

endophyte communities. The movement of plants by humans also plays a role: a study in southern Arizona suggests that non-native trees harbor more abundant but less diverse endophytes, and less specialized endophytes, relative to closely related natives.

Ecology and applications of endophytes

Because most endophytes isolated to date in Arizona represent undescribed species, we are at the tip of the iceberg in terms of understanding their ecological roles. Why do they not act as virulent pathogens of their hosts? Are they distinct from decay fungi that break down leaves and wood? Where do they persist in the environment when not in living leaves? What are the costs and benefits of their presence within host plants?

Each of these questions is a topic of current interest in endophyte biology, and with the exception of pioneering work by a few researchers (*e.g.,* Stanley Faeth, Arizona State University, who has examined endophyte symbioses in Arizona's native grasses and oaks), we know woefully little about the interactions, evolutionary history, and ecology of the endophytes that inhabit our state's native and introduced plants. Studies conducted elsewhere have shown that some endophytes enhance resistance to pathogens and protect plants against insect pests and herbivorous mammals, whereas others increase susceptibility to drought or decrease plants' photosynthetic efficiency. Studies in the temperate zone by researchers such as Regina Redman and Rusty Rodriguez have demonstrated that some endophytes can confer heat tolerance or salinity tolerance on their hosts.

Together, these findings have inspired collaborations between endophyte biologists and applied scientists working in natural products chemistry, medicinal drug discovery, biological control, and industrial sciences. Endophytes are now recognized as a remarkably promising source of new compounds, new medicines, alternatives to pesticides, and new products for use in bioremediation and biofuels development. Recently, several novel compounds with anti-cancer activity were recovered from an endophyte from Mt. Lemmon; other endophytes in our collection are adept at degrading cellulose, a key for alternative fuel development. Arizona's rich array of endophytes is thus one of our little-known but exceptional natural resources.

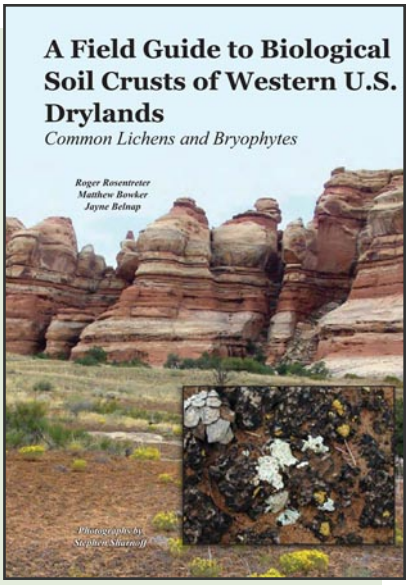
Perhaps more than anything, early studies of endophytes in our state and beyond suggest an array of ecological roles, biochemical attributes, and potential uses that are at least as diverse as the endophytes themselves. Far from discouraging, this highlights the draw these fungi have for me as a scientist and a student of Arizona's biodiversity — and the wide-open nature of endophyte biology for those interested in understanding cryptic and previously unexplored interactions between plants and their little-known symbionts.

BOOK REVIEW

by C. Douglas Green, Phoenix Chapter President

A Field Guide to Biological Soil Crusts of Western U.S. Drylands: Common Lichens and Bryophytes (Mosses and Liverworts)

by Roger Rosentreter, Matthew Bowker and Jane Belnap, with photos by Stephen Sharnoff. U.S. Government Printing Office, 2007.



Two years ago, I visited Canyonlands National Park and Arches National Park at Moab in SE Utah—-both of which are gorgeous places. While there I had a number of opportunities to see different 'Biological Soil Crusts' or BSCs. Most of the areas occupied by BSCs were marked off by the National Park Service as being crucial to the well-being of the ecology of these parks — "so be extremely careful not to tred upon these thousands of years old surfaces."

Then recently in reading a copy of *The Sego Lily*, newsletter of the Utah Native Plant Society, I read a book review about this appropriately titled field guide, which can be ordered at no charge from the following:

Christy Parry
USGS, BRD, SBSC, Canyonlands RS
2290 S. West Resource Blvd., Moab, Utah 84532
Phone: 435-719-2359, Fax: 435-719-2350
cparry@usgs.gov

So I ordered the 100+ page spiralbound Field Guide with its clear protective cover from Christy by email, and, lo and behold, I had my FREE copy within 1-2 weeks. Great service! This is an excellent guide with dynamite information about BSCs, mosses and liverworts (bryophytes), and soil lichens. Most of the guide is devoted to the biodiversity of the Western U.S. in regards to the above botanical species.

As a result of this guide I am better equipped to understand the BSCs of both Canyonlands and Arches National Parks, as well as the soil lichens and bryophytes which live within or on top of the uppermost millimeters of soil. These unique communities (also known as cryptobiotic, cryptogamic, or microbiotic communities) include soil particles and cyanobacteria, green algae, bacteria and microfungi. BSCs cover dryland surfaces that are not necessarily infused with trees, shrubs, grasses, cacti, etc. and can comprise over 75% of the *living ground cover.* It is no small wonder that these BSCs are so coveted at these two national parks, as they do provide for stable soil, nutrients, and moisture.

The depictions describing crust morphology are well illustrated in full color and target smooth, rugose, pinnacled, and rolling crusts. All of the photos of mosses, liverworts, and lichens are in full color, and are often in full size and with enlarged views adjoining in some cases. The authors do a nice job of showing a map of the areas of growth, as well as elevations at which one can expect to view these botanical taxa. I liked the taxa descriptions, habitat descriptions, and general comments about them as well.

Overall this is a very nice compact field guide that presents excellent photos and drawings so that one can readily identify most soil lichens, mosses, and liverworts likely to be seen in the western drylands of the U.S.

ENJOY! I have!

Canotia, a new journal of Arizona Botany, has been created to publish newly-updated parts of the *Arizona Flora* and connected research. You can download copies online at http://lifesciences.asu.edu/herbarium/canotia.html. This is also where you can also elect to receive an email when new editions become available.

ETHNOBOTANY: PEOPLE USING PLANTS

The Supai Sunflower Saves the Day

by Jessa Fisher, Flagstaff Chapter President. Photo courtesy Suzanne Nelson, Native Seeds/SEARCH.

Plants provide people with many things, the most important of which is food. Indigenous farming societies around the globe have been slowly and gradually adapting food items to individual microclimates for centuries by using various methods of cross-pollination. Through this lengthy process different strains of seeds eventually developed, adapted for particular local sunlight, water, soil, and temperature conditions. Each year seeds were saved for next year's crop. This natural progression of seed evolution has produced in the present day many "heirloom" varieties of plants. These varieties, rarely found at the grocery store, hold important genetic diversity within crops which ensures survival through tough environmental conditions.

Not only were unique crops eaten in these ancient agricultural systems but the wild "weed" species that favor disturbed areas, such as the edges of a hand-plowed field, added to the diversity of a meal. This phenomenon is still seen today in developing countries. While in the US today we regularly eat between 15-30 plant species at our meals, in South Africa 350 plants are regularly eaten, with wild foods supplementing staple crops. This diversity is important for humans to ensure a balanced diet with all trace vitamins and minerals. As well, the plant diversity is healthy for a balanced environment, with different plants attracting different pollinators.

One local example of the importance of crop diversity is with the Havasupai (Supai) sunflower. The Supai tribe, living in the harsh environs of the Grand Canyon, bred different varieties of sunflowers adapted to their hot, dry, sandy climate. Two strains of Supai sunflowers came to international attention when it was discovered that they were resistant to a rust which was threatening sunflower crops in Australia. The Supai gave seeds to the Australians who then crossbred the Supai sunflower with the Australian sunflower to create a rust-resistant strain suited to grow in Australia. If the Supai hadn't bred their particular strains, or been generous with their seeds, the Australian crops would have been ruined.

In these modern times, fewer and fewer crops are being grown world-wide, with seeds that are artificially manipulated by humans. The shrinking diversity in crops and wild edible species found in modern day factory farming is a threat to healthy ecosystems and international food security. As well, unnatural food manipulation such as genetically modified organisms (GMOs) and terminator seeds are not only risky to human and pollinator health but are designed by rich corporations to keep poor farmers poor. One thing you can do about this is to buy and plant heirloom seeds in your garden to attract a wide variety of pollinators and to keep the natural cycles of nature alive.

For more information on heirloom seeds go to the Native Seeds/SEARCH website at **www.nativeseeds.org**.

For more information on food security and biological diversity, go to the Convention on Biological Diversity (CBD) website at **www.cbd.int**.

The Havasupai Sunflower grows in sandy soil on the Supai Reservation in the Grand Canyon.

above Montana State University students scan plots for grass seedlings for graduate research on restoration.

Grand Canyon Trust Volunteers: Partners in Protecting Biodiversity

by Kate Watters[1]*. Photos courtesy the author.*

The Colorado Plateau is home to some of the most spectacular scenery in the world. This diverse landscape of desert canyons, high alpine meadows, forests, desert grasslands, and pinyon-juniper woodlands is also home to a vast and interesting flora. The Plateau has incredibly rich plant diversity with 300 endemic plant species, many of which are found nowhere else in the world. There are most likely many others yet to be discovered and described. The region also has some of the highest proportions of globally rare native plants in the country, with 27 plant species that are listed as threatened or endangered by the U.S. Fish and Wildlife Service.

Historic and current land uses such as overgrazing, logging, fire suppression, urbanization, multiplication of roads and off-route driving, and water development have contributed to the decline of many sensitive plants. There is a great deal of research to be done and actions to be taken to solve the complex web of problems that threaten the diverse habitats on the Colorado Plateau. Public land managers with tight budgets are increasingly embracing the assistance of volunteers in better understanding and managing the Plateau's rich biodiversity. This is where the Grand Canyon Trust and its volunteer program become an integral part of the story.

The Grand Canyon Trust is a regional, non-profit conservation organization whose mission is to protect and restore the Colorado Plateau by advocating for collaborative, common sense solutions to the environmental challenges affecting this region. The Trust partners with the National Park Service, Forest Service, and Bureau of Land Management, Utah Division of Wildlife Resources, and the Arizona Game and Fish Department to help them maintain and restore public lands. The secret for making this happen is the outstanding work of dedicated volunteers.

In 2005, the Trust purchased the Kane and Two Mile Ranches (K2M) in partnership with The Conservation Fund. The ranches hold the livestock grazing permits for approximately 850,000 acres of public lands north of the Grand Canyon that are managed by the U.S. Forest Service and Bureau of Land Management. The grazing allotments span from Kanab Creek to the Paria River, and include House Rock Valley and the Vermilion Cliffs National Monument, which is comprised

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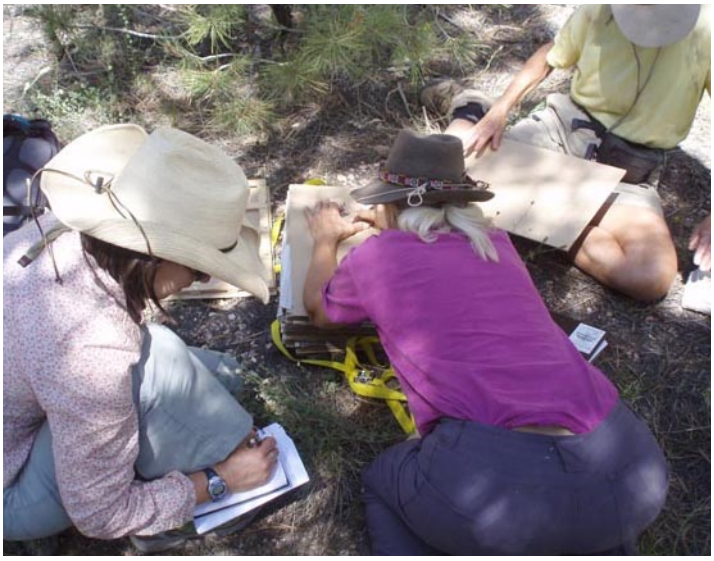

above, from left Monitoring Springs in the Paria with Lewis and Clark College students. **right** Volunteers help Trust graduate students collect voucher specimens for Warm Fire research.

primarily of Paria Plateau. Since 2005, the Trust has initiated a series of prioritized, restoration projects to improve and maintain the deeply embedded ecological, cultural, and scenic values across this vast and ecologically important landscape. The work that Grand Canyon Trust volunteers have accomplished on the ranches has bolstered the capacity of agencies to accomplish landscape-scale, conservation-oriented management of these public lands.

Shortly after the purchase, the Grand Canyon Trust conducted a baseline ecological assessment of the ranches to measure historic and current conditions and to help identify restoration opportunities and management needs. The baseline assessment entailed gathering data at 660 plots to characterize rangeland, forest, and water resource conditions across the ranches, from mixed conifer to desert grassland ecosystems. One of the first volunteer projects was to measure forest overstory characteristics on the Kaibab Plateau.

Since 2005, volunteers have contributed over 25,000 hours to on-the-ground projects on the ranches and have helped the Trust and the agencies make solid progress towards achieving conservation goals. The work accomplished by the volunteers is equivalent to 11 full-time federal employees, a fact which is not lost on land managers struggling with declining budgets. Equally importantly, they have helped to build partnerships with key land management agencies, and have made it clear that conservation is actively supported by a broad cross-section of citizens locally, regionally, and nationally.

This spring the Trust began an ambitious effort to remove tamarisk and Russian olive from a 17-mile stretch of the Paria River in partnership with the Bureau of Land Management and with funding from the Arizona Water Protection Fund. Since this river corridor was retired from grazing in 1999, it has remained a high priority for restoration. Volunteers and field technicians worked side by side to complete baseline ecological monitoring by collecting data that will help determine how the removal of exotic plants affects native vegetation recovery, channel form, and breeding bird populations in this unique ecosystem. Removal efforts will begin this fall, fueled largely by volunteer labor, and will be ongoing for the next five years.

In an effort to continue building a science foundation for the K2M project, volunteers have provided invaluable assistance to a post-doctoral fellow in conservation biology and graduate researchers from Northern Arizona University (NAU) that are working closely with the Trust. Volunteers assist with research projects that seek to describe Kaibab Plateau forest conditions, determine how overstory and understory vegetation recovers after fire, study how grazing livestock after a fire affects vegetation, and document and explore how differences in forest management between Grand Canyon National Park and the Kaibab National Forest have resulted in very different ecological characteristics.

This year the Trust partnered with the Arizona Native Plant Society, Desert Botanical Garden, Forest Service, Northern Arizona University and Museum of Northern Arizona (MNA) to begin a statewide effort to document the plant diversity of Arizona through the Plant Atlas of Arizona Project (PAPAZ). "Budding Botanist" volunteers learn in the field and in the classroom about plant identification, how to collect plants, and how to make herbarium specimens. Volunteers joined regional botanists in beautiful Barbershop Canyon near the Mogollon Rim to learn how to collect plants. PAPAZ also sponsored a classroom training opportunity for volunteers at MNA where they learned the basics of plant morphology, how plants are classified, the process of mounting herbarium specimens and toured MNA's herbarium collections. These botanists-in-training are critically important for documenting botanical diversity throughout the Plateau.

In addition to the work on the K2M project, the Volunteer Program has been expanded to include work in Grand

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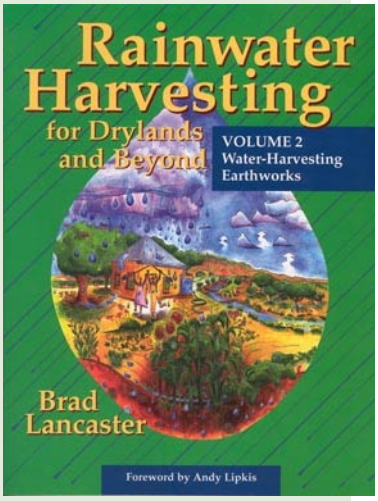
BOOK REVIEW

Rainwater Harvesting for Drylands and Beyond Volume 2: Water-Harvesting Earthworks

by Brad Lancaster. Rainsource Press, Tucson 2008



by Julia Fonseca, Tucson Chapter, AZNPS

Whether you are tired of high water and electrical bills, want a different landscape look, need to solve drainage problems, or are looking to contribute to your community or environment, productively using rainfall and greywater can enrich your life. This book shows you how to design and create water-harvesting earthworks, in a most engaging style. Imagine if a Peace Corps volunteer were sent to your urban village to invite you, persuade you and demonstrate to you how to have more fun in your garden.

If you were frustrated with Volume 1's lack of practical detail, this is the book you'll want. Volume 2 covers everything from check dams, compost, mulch, swales, streetscape opportunities, greywater system design, and a wide variety of basins at many different scales. It is full of inspirational stories and ideas, and offers a wealth of tables and references. Helpful graphics, drawn from real-life examples, are one of the strengths. Volume 3, yet to come, will address cisterns in detail for those of you with "tank envy."

Chapter 11 and a related appendix discuss how to integrate plantings with rainwater harvesting features. Plant placement and form are discussed, but so are many individual species, with a focus on edible landscaping and native plants suitable for low, warm deserts of Arizona. This is a unique strength of the book for our purposes.

Lancaster's approach is rooted in "permaculture" principles, to which he adds years of experience and observation at a variety of watershed scales. One of the pleasurable aspects of reading the book is seeing how the principles come together in design, and understanding how much is encompassed in the "circle of concern" created by rainwater harvesting practices. Rainwater harvesting re-orients city dwellers to their landscape in a way that xeriscape does not. By combining water harvesting with native plants, Lancaster is showing how to re-orient landscape design toward wildlife and a more enjoyable, livable city life. It fits perfectly with AZNPS's "Grow Native" message!

The only thing that I find wanting is more information about soils and the effects of natural soil layering upon water retention and plant selection. Lancaster does present important research regarding caliche (a calcareous soil horizon) and tree planting, but readers are presented with little additional guidance to understanding one of the most important and variable aspects of their environment.

by Gary Bachman, Tucson Chapter, AZNPS

When I was asked to do this review, it just happened that one of my graduate interns asked if I had any favorite landscape architecture books. *Rainwater Harvesting* was my answer.

Rainwater Harvesting may not have necessarily changed the thinking of many professionals, but it has reinforced and validated ideas, hunches, concerns, inclinations amongst those who have always believed that there are better ways to develop than our current wasteful and hurtful practices. The book elevates from our subconscious what we have always believed, that our reason for landscaping and using native plants is "to enhance our local resources, rather than deplete them."

Since an encounter in the late 70s with Bill Mollison, I considered permaculturists to be somewhat elitist. We were working on shifting Australian plant consciousness away from Mediterranean exotics (such as Oleanders) to local plants. When asked about native plants, Mollison called them "useless." (true!).

Not so for Brad, an AZNPS member. Brad advocates the use of native plants, suggesting a definition that places plants within the local geography and ecology. If few native plants have survived in a locality, he says, "Bring the natives back!" How do you learn about plants and their needs, "TAKE A HIKE!" and, I might add, "attend AZNPS Chapter meetings and field trips," which Brad did more than a few years ago.

He has been an innovator for sometime, carting around a mill and hosting neighborhood festivals to tell us the message about mesquite flour. Attentive, friendly, and open

BOOK REVIEW *continued*

to new ideas, I had no idea that he was assembling an incredible and eclectic array of information found in *Rainwater Harvesting* (Volumes 1 and 2). My observation was — this is the person who walks his talk. He hasn't changed. He arrived for a recent workshop on bicycle, with a box of books, a bundle of plumbing devices, laptop computer and wide brim hat in tow. He deeply believes in what he is doing, and has the confidence not to take it all too seriously.

The ideas are compelling that a consensus has developed, at least in Tucson, that is leading to changing of building codes to require greywater and water harvesting systems and a major road widening project which will incorporate water harvesting demonstrations.

"Begin with long and thoughtful observation," is the first principle of the eight that are suggested for Rainwater Harvesting. How different would our lives be if this principle, as well as the other seven governed the layout of our urban communities? To the landscape architect, this first principle is site analysis. How often are observations collected, and then put away, never to be seen again? I agree, site analysis is the most critical and challenging part of the design process. It may take many seasons and plant walks to come to an understanding of the demands of the sun, winds, soils and seasons on a site.

Brad is no cynic. His cure is the shovel and a pile of rocks. This may contradict the "careful observation" concept, but Joe Valer comments about the 20,000 check dams that have lead to the restoration of the Coronado Ranch in southeast Arizona, "If I had been told that I needed to put in 20,000 stone structures I'd still be thinking about that."

Rainwater Harvesting is full of stories, case histories, facts, solutions, equations, tips and references. There are chapters devoted to berms, terraces, French drains, basins, imprinting, mulching, paving, swales, check dams, vegetation, and finally greywater harvesting. While Tucson and dryland communities may be the focus of Brad's explorations, examples from the arid west and around the world are included. The principles are not restricted to arid communities, but applicable to anyone concerned about preserving resources. This is not just a home landscaping manual, but a guide to restoring whole landscapes. All the information that you need may not be in this book, but with ample references you may be able to get to where you need to go.

So, what do native plants have to do with all this? He suggests a prejudice towards the use of native plants, and recognizes the need to grow exotic plants for food, shelter, and other uses. The primary value is to restore habitat, to make our cities more comfortable, to attract wildlife. Though I have not asked, I suspect it is up to us to enhance his plant lists with more contributions based on our experiences and observations on native plants.

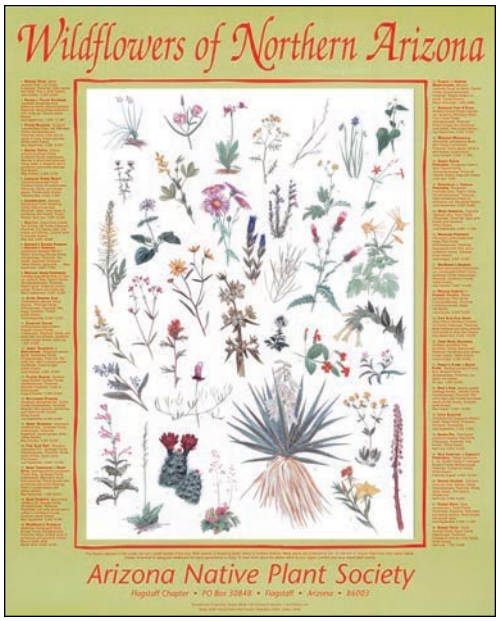
Finally, a quote from an article by Brad in *Restoring Connections* newsletter of the Sky Islands Alliance (Summer 2008), "The idea is to live our daily lives in such a way that we enhance our local natural resources rather than deplete them, and to have fun as we do it." That is why I recommend that you find this book, get your shovel, start observing and enjoy the changes.

Grand Canyon Trust Volunteers *continued from page 19*

Canyon National Park and Native America. In the Spring of 2008 volunteers also worked with members of the Navajo Tribe to identify important cultural and medicinal plants along the trail at Second Overlook Gorge on the Little Colorado River and will help create interpretive signs for visitors.

GCT volunteers also contributed their much-needed botanical skills to the Trust's Utah Forests Program, revisiting plant transects where data had not been collected in 30 years and surveying for reference plant communities in the Fishlake National Forest. These projects are located within the Tushar grazing allotments, which are the subject of the two-year Tushar Allotments Collaboration. This collaboration is co-sponsored by the Trust and has 21 participants (including grazing permittees, conservation groups, Fishlake National Forest and Utah Division of Wildlife Resources staff, a County Commissioner, and the Utah Farm Bureau) who are jointly examining the allotments and who will propose solutions for the problems they observe. Volunteers continue to be an important part of this process.

Through opportunities provided by the Grand Canyon Trust volunteer program and Arizona Native Plant Society, volunteers are becoming increasingly equipped with skills and knowledge to help better understand, protect, and restore the Colorado Plateau. This growing extended family of citizen stewards not only cares about the fate of the Colorado Plateau, but by volunteering their skills and sharing their passion they are a critical part of the effort to ensure the magnificent and irreplaceable biodiversity of the Plateau is not lost. To join us visit our website: **www.gctvolunteers.org**.



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Questions? Sending an international order? Please contact Nancy Zierenberg at **aznps@aznps.org**

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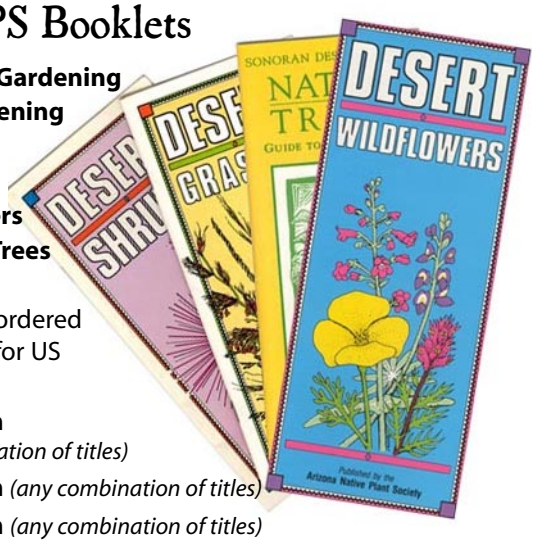

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Would you like to take a more active role in protecting Arizona's native plants? There are open Board positions — please contact any of the above board members for more information on how you can get involved. You can also contact your local chapter (see back cover) for local volunteer opportunities.

The Arizona Native Plant Society

Upcoming Issue

Restoration of Arizona Wildlands

Contact *The Plant Press* Technical Editor, Barbara Phillips, at **bgphillips@fs.fed.us** for more information on contributing articles, illustrations, photos, or book reviews on this topic… as well as themes you'd like to see us cover in future issues.

The Plant Press is a benefit of membership in the Arizona Native Plant Society. Suggestions are welcome for book reviews, and articles on plant use, conservation, habitats, and invasive species

New Members Welcome!

People interested in native plants are encouraged to become members. People may join chapters in either Phoenix, Flagstaff, Prescott, Tucson, Yuma, or may choose not to be active at a chapter level and simply support the statewide organization. For more information, please write to AZNPS at the address below, visit the AZNPS website at **www.aznps.org**, or contact one of the people below.

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