The Plant Press

THE ARIZONA NATIVE PLANT SOCIETY

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The Arizona Native Plant Society

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Restoration of Arizona's Wildlands

& Our Regular Features:

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above Santa Cruz River floodplain at Esperanza Ranch conservation easement. *Photo courtesy Kendall Kroesen.*

Tucson Audubon's Restoration of Arizona Wildlands

by Kendall Kroesen, Restoration Program Manager, and Lia Sansom, Restoration Specialist, Tucson Audubon Society

Introduction

Tucson Audubon has been restoring habitat in desert riparian settings since 2000. All work has taken place in the Santa Cruz River watershed with two project sites along the lower Santa Cruz River in northern Pima County and one on the upper Santa Cruz River in Santa Cruz County. A fourth very small project site is in a spring-fed canyon in the Tortolita Mountains. Tucson Audubon also has plans to work at a more urban location along a wash on the east side of Tucson.

The restoration program is heavily influenced by Tucson Audubon's conservation priorities. These include riparian research, conservation and restoration, in some cases targeting particular bird species. The Santa Cruz River is an area of major riparian habitat loss with significant impacts in the previous century from grazing, erosion, channelization and groundwater pumping. However, the river was also seen as an opportunity due to the potential for reestablishing xeroriparian vegetation and, downstream from Tucson, the

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

President's Note

by Barbara G. Phillips **bgphillips@fs.fed.us**

Coconino, Kaibab and Prescott National Forests, Flagstaff

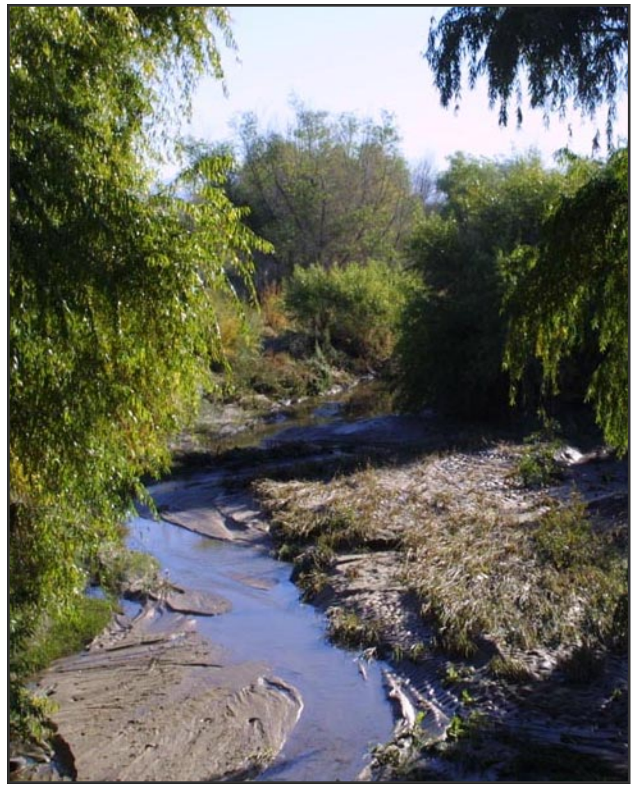
We would like to dedicate this issue of *The Plant Press* to Tom Moody, who died in January while flying from Flagstaff to Yuma for a wetlands restoration project. Tom and his wife, Stephanie Yard, were co-owners/engineers of Natural Channel Design, an innovative ecological restoration company. His legacy lives on in the Yuma Wetlands and Willow Wash at the Arboretum at Flagstaff (featured in this issue), as well as at Hart Prairie Preserve, Fern Mountain Botanical Area, Coconino National Forest, and Picture Canyon in Flagstaff.

You may note the absence of a few of our regular features in this issue. Frankly, we ran out of space! Our authors provided very interesting lengthy articles and since this whole issue is devoted to wildland restoration and one long article features the very interesting life history of the native buckbrush, we decided to skip the "Conservation Committee Update" and "Focus on a Native Plant" features, as well as the book review. These columns will return in future issues.

We wish to thank the following State Board members for their efforts on behalf of the Arizona Native Plant Society. Jessa Fisher has been our State Secretary and *Happenings* Editor for three years. Ken Morrow has been our State Treasurer for many years. And during his short tenure as Yuma Chapter President, Shawn Pollard contributed to AZNPS at the local and state levels.

We now welcome Suzanne Cash as our State Secretary. Ana Lilia Reina-Guerrero, and Tom Van Devender were recently elected to two-year terms on the Board, and Andrew Salywon and Kendall Kroesen were elected to one-year terms. We look forward to their contributions at the State level of our Society.

above Meeting of existing permeable fill road (1999) Hart Prairie Preserve, and new road, Fern Mountain Botanical Area, (2008), looking south. Natural Channel Design. Bebb's willow trees on both sides of road.



above Santa Cruz River at North Simpson Farm.

opportunity to work in the effluent-dominated reach where limited cottonwood-willow vegetation was emerging spontaneously.

In this account we will focus on the three sites along the Santa Cruz River, primarily the North Simpson Farm where we have the most experience. These sites have a few things in common like long term, heavy degradation from either farm or cattle use or both. The river along all of these sites flows nearly year-round because of effluent releases from wastewater treatment plants upstream, so all have some natural cottonwood and willow recruitment in the river channel. High-intensity, fast flows from summer rains prevent us from doing much work along the river as plantings and irrigation there are often washed out. Therefore, our work generally focuses on the xeroriparian, upper floodplain regions of our sites. Fencing is a priority on all sites to exclude cattle. However, all three Santa Cruz River sites have continued to experience cattle incursions from neighboring properties. After eight years of work the restoration program is in the process of assessing overall effectiveness and exploring new directions.

North Simpson Farm

Tucson Audubon restoration work began in 2000 at the North Simpson Farm, a 1,700-acre parcel owned by the City of Tucson. The City has purchased and retired from cultivation some old farms in the Santa Cruz River floodplain in Avra Valley. A 1.3-mile reach of the effluent-dominated stretch of the river flows through the site, which is located west of Trico Road about two miles south of the boundary between Pima and Pinal counties. Early in the planning stages of Tucson Audubon's involvement in this site, we decided to focus our work on the northeast corner of the site and along both sides of the river where unreinforced earthen berms were built along the active floodway after major floods in 1983 and 1993.

Restoration at this site has been accomplished with in-lieu mitigation funds from the Army Corps of Engineers enforcement of the Clean Water Act, grants awarded by the Arizona Water Protection Fund Commission, additional funding from the Arizona Partners for Wildlife program of the U.S. Fish and Wildlife Service, and important in-kind contributions from the City of Tucson.

above Artificial river berm along Santa Cruz River at North Simpson Farm.

Prior to on-the ground work, a site assessment was prepared for the Simpson site in order to guide our restoration efforts. Information was gathered on a variety of site components including site history, watershed, hydrology, topography, climate, and existing and potential flora and fauna. Site goals were created by combining information from the site assessment with the principles of Permaculture, a systems approach to integrated design of agriculture and human settlements. Some of the Simpson site goals are:

1) Increase vegetation using sustainability techniques such as rainwater harvesting, mulching, seed pelletization and others
2) Focus recovery work on species selected for their appropriateness to conditions at this site to create more diverse habitat, increase stability and fertility of site soils, stabilize erosion-prone areas, and displace nonnative invasive species
3) Integrate the river with adjacent land outside flood control berms to improve habitat connectivity on the site
4) Monitor site conditions to determine impacts of restoration work so strategies can be adjusted if needed to increase benefits
5) Encourage public participation in site work to support stewardship of the site, increase understanding of riparian areas in the Sonoran Desert ecosystem, and provide nature-centered opportunities for the community.

None of our goals include a desire to return the Simpson site to a historic condition. This area has been vastly altered by agriculture for an extensive amount of time and the hydrologic regime has been altered by the perennial flow of effluent in an area that was historically ephemeral and by flood control berms that changed the effects from flooding. Therefore our plant palette, for seeds and containerized plants, consists of native xeroriparian plant species suitable to the present site conditions and that provide forage, cover and nesting sites for native birds and other wildlife. In a strict sense of the word, this is not "restoration" but probably fits better under another label like reclamation, revegetation or habitat creation. However, since much of our program is outreach-based, we find that the public relates best to the term "restoration."

The ideal way to address Goal 3 probably would be to regrade the earthen berms along the river to allow overbank flows and channel meandering. This could possibly extend the mesic, and perhaps hydric, plant communities that are constrained by these berms. But this is impossible to achieve in the short term due to active farmlands that could be impacted by floodwaters exiting the Simpson Farm. With this impediment, Tucson Audubon restoration staff saw an opportunity. The berms provide microclimates in an otherwise exposed flatland to assist in quickly establishing a dense variety of plants. With their relatively steep incline,

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Tucson Audubon's Restoration of Arizona Wildlands

continued

above Drip irrigated vegetation being established at Martin Farm.

many micro-catchment basins could be hand-dug in close proximity to each other that would collect rainwater in even minor rain events with little sheet flow. Plants in these basins received initial supplemental irrigation but were rapidly and successfully removed from irrigation after two years. It is our hope that the plant communities on these slopes are able to provide a seed source and spread as time passes and the berms slowly erode away.

Extending xeroriparian vegetation away from the river, up the berm and into the floodplain outside the berm helps to achieve Goal 3 in the sense of vegetative connectivity.

Until recently, most of our restoration work involved a combination of seeding and planting. Early in the project, large areas of the floodplain northeast of the river were imprinted and seeded. Seeded areas were not irrigated. Initial results suggested reasonable growth of annuals and wildflowers from seed in the first spring season, particularly of a seeded *Plantago* species. However, we have not seen significant establishment of most seeded species, particularly woody species. The exceptions to this are two saltbushes, *Atriplex canescens* and *A. polycarpa*, which have grown from seed at rates that have contributed to reestablishment of vegetative cover.

In addition to seeding, we planted native xeroriparian plant species in a relatively dispersed manner (100-150 individuals per acre). These were planted along drip irrigation lines installed for this purpose. Short-term survival of plantings has been relatively good but long-term survival has been decreased in some areas by intense competition from invasive plants, especially the invasive exotics Russian thistle (*Salsola* sp.) and Bermudagrass (*Cynodon dactylon*).

We initially underestimated the tenacity of invasive plant species at the Simpson site. Our early strategy was as quickly as possible to get beyond the early stages of succession so that natives, particularly woody shrubs and trees, would begin to "shade out" or otherwise compete with exotics. Thus far we have purposefully avoided the use of any herbicide. We innovated some techniques such as crushing thick growths of Russian thistle into a "mulch mats" that were thick enough to make it difficult for new Russian thistle seedlings to germinate and grow. However, the ground had to be exposed in areas where transplantation was to occur and we were not prepared for the overwhelming number of weeds, particularly Russian thistle, that would grow along our irrigation lines and compete with our transplants. The mulch mats were helpful for a season or two in the areas with the thickest infestations, but that did not help immediately around the transplants, or where mulching did not provide a thick enough mat.

Tucson Audubon Society has a 99-year right-of-entry agreement with the City of Tucson to do restoration work on the Simpson Farm. This provides us with ample opportunity assess our work and reassess site conditions to determine the best methods for habitat establishment. We monitor the site through a variety of methods to aid us in our continual reassessment. Monitoring activities include avian surveys, repeat photography, survival and growth of plantings, vegetation structure, and river channel morphology. In the near future, our efforts will focus on more intensive invasive plant control, particularly of Russian thistle, and denser native plantings.

Martin Farm

The Martin Farm is about one mile upstream (southeast) from the North Simpson Farm, off of Trico-Marana Road. It also straddles the Santa Cruz River, though the restoration project site is limited to about 30 acres located on the southwest side of the river. The restoration area again lies mostly in the river's floodplain, although the river's floodplain is much narrower here than it is at the North Simpson Farm.

Restoration at the Martin Farm has been provided by in-lieu mitigation funds.

The restoration area at the Martin Farm varies from North Simpson Farm in that it was never farmed but has been grazed. Prior to restoration work, limited numbers of velvet mesquites, catclaw acacias and Mexican paloverdes were present on the floodplain in a higher density than at the North Simpson Farm. However, the density of cottonwoods and willows close to the river is much less than at Simpson.

The bulk of the restoration efforts took place on an upper floodplain terrace, which flooded in the major flood of summer 2006 prior to restoration work. This encouraged a thick growth of summer annuals. The flood and the thick insulating cover may have enhanced soil moisture and contributed to the fairly good survival of plants transplanted early in 2007. Irrigation of transplants used water pumped from the river through a drip system. Plants were irrigated, when necessary, through spring of 2008, and rarely since then.

The project has experienced relatively high plant survival and growth rates at this site. Perhaps because of more intact soil nutrients and perhaps more of a native annual seedbank, exotic invasives have been less problematic here with the exception of Bermudagrass, which has crept into more of our irrigated areas in the course of this project.

Esperanza Ranch

Esperanza Ranch is an 800-acre private parcel located along the upper Santa Cruz River between Tubac and Amado, in Santa Cruz County. This riparian restoration project is located on a 300-acre conservation easement within the ranch site that is managed by Tucson Audubon.

The easement largely lies on floodplain land along the west side of the Santa Cruz River and along the Chivas Wash, a tributary that enters the floodplain from the west. Restoration work here has been funded by the Esperanza Ranch endowment provided by Devon Energy Corporation, the Arizona Water Protection Fund Commission, the George A. Binney Conservation Foundation, the Wallace Research Foundation and a grant from the Environmental Protection Agency administered by the Sonoran Institute.

Part of a historic ranch, large parts of the easement have been farmed and heavily grazed. In large areas of the western floodplain that lie above the active river channel floodway, weedy native carelessweed (*Amaranthus palmeri*) grows extremely densely with the commencement of summer rains. The goal of revegetation on the floodplain is to create areas of mixed native shrub and grassland, grading into denser mesquite bosque closer to the river and along the wash (similar to reference areas farther south along the river).

Initial strategy at the site called for hand-seeding over large areas and extensive, rather than intensive, transplantation of seedlings. Both seeds and transplants are not irrigated due to a prohibition on groundwater pumping at the site and the desire to experiment with more water harvesting techniques at a larger scale. Survival of the initial plantings was about 30% after three years, which exceeded expectations as many of the plants were installed during a particularly hot and dry summer.

above Santa Cruz River at Esperanza Ranch conservation easement.

As at the North Simpson Farm, hand distribution of seed has not proven to be particularly effective. Inability to control moisture levels may be a factor, as well outcompetition by extraordinarily thick carelessweed in the summer season. Populations of some spring annuals may have been enhanced by seeding.

Lessons learned at this site are similar to those at the North Simpson Farm. We are moving towards more intensive restoration efforts in smaller areas where we can control invasive plants more effectively and transplant denser stands of desired native plants. We are currently experimenting with carelessweed control plots to create relatively small areas of intact native vegetation.

Conclusion

Riparian zones along many parts of the Santa Cruz River are desiccated and contain depauperate plant communities. They do not support the diversity of wildlife of which they are capable. Because of historic changes in these floodplains, and because of potential future climate change, it does not make sense to attempt to restore to any particular past condition. Tucson Audubon is using an adaptive management approach to restoring functioning ecosystems that will support a wide array of wildlife under current and future conditions. We hope to support nesting, wintering and migrating birds as well as other wildlife species that use riparian resources or corridors.

figure 1 A photo of Willow Wash and the field of weeds prior to construction. Note the carpet of smooth brome.
figure 2 (inset) An example of what can happen when we tamper with natural hydrology. This photo was taken in 2003 or 2005.

From Field of Weeds to Riparian Hotspot:

The Rehabilitation of Willow Wash at The Arboretum at Flagstaff

by Kris Haskins, The Arboretum at Flagstaff

The Arboretum at Flagstaff is home to many diverse habitats that highlight the Colorado Plateau's native flora. Since 1981, when The Arboretum first opened, efforts have been made to create and expand unique gardens for visitors to view the wide array of plant life that the Colorado Plateau has to offer. Our most recent endeavor, Willow Wash, has added three new acres of gardens to the existing ten acres already under cultivation. Willow Wash features three different riparian habitats and their associated native plant life: a permanent spring, an ephemeral stream, and a depressional wetland (see Table 1 for species list). The story of how this project came about is an interesting one.

Few people realize that the 200 acres of land that Frances McAllister originally donated to create The Arboretum was actually a former working cattle ranch. Records reveal that the property had been a cattle ranch for at least 20 years. An old water tank and cattle chutes are still visible in the meadow today. As many folks in the West are aware, cattle ranching and native flora do not have a history of peaceful coexistence and the flora typically lose out to the cattle. This scenario describes what happened at The Arboretum as well. The years of cattle grazing eventually took their toll and created a weed field from the once native meadow (figure 1). However, the cows were not the only ones at fault. The ranchers in charge of the land actually planted the exotic grass, smooth brome *(Bromus enermis*), for the cows as forage, but as luck would have it, the cattle preferred the native bunchgrasses! The cattle also damaged the wash that flowed through the property. The wash, which is an extension of Sinclair Wash, had been altered by years of cattle and anthropogenic use and no longer funneled excess runoff water the way it should (figure 2). Thus, a major project was born.

There are many reasons why you might want to rehabilitate a damaged habitat. However, the biggest reason is often to bring back biodiversity of native flora and fauna. One of our mission goals at The Arboretum is to provide the visitor with a glimpse of the diversity of vegetation and habitat types they might expect to see across the Colorado Plateau, including riparian areas. A less thought-of reason to correct the damage done by cows and humans over the years would be to return ecosystem functions to the site. These ecosystem functions might include nutrient cycling rates and water transpiration,

figure 3 Construction of Willow Wash in 2008. The hardscaping phase exposed a large amount of soil, but created the necessary features for the riparian habitats.

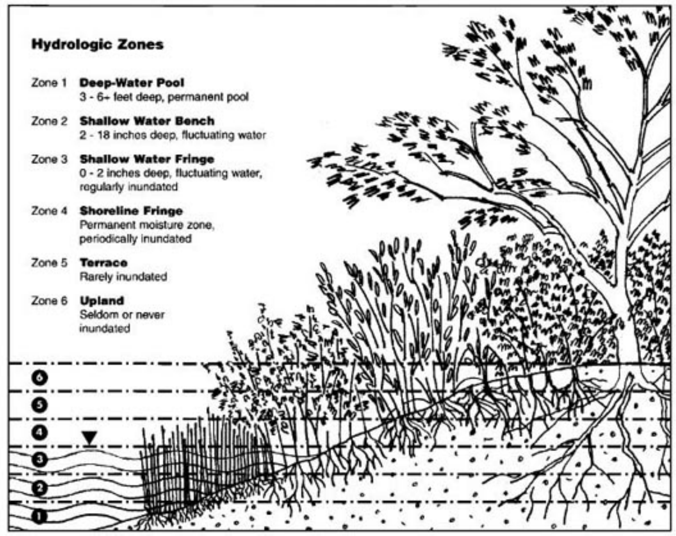

figure 4 An illustration of different riparian zones. The Arboretum will feature zones 2-6.

both of which can be altered by changes in vegetation. It is amazing, when you think of it, how replacing native flora with a weed field alters the entire ecosystem, from the types of organisms and the texture of the soil to litter decomposition rates and the rate at which nitrogen and carbon filter through the system. Needless to say, this was going to be a large undertaking for the crew at The Arboretum.

As with any major project, the first step was to come up with a design that was functional, aesthetic, and informative. To accomplish the functional goal the wash was going to have to be re-channeled to alleviate the risk of flooding and to create the desired aquatic environments. Furthermore, a permeable embankment needed to be created to protect surface flow hydrology. Natural Channel Design, Inc., of Flagstaff, Arizona was contracted to assess the meadow site and prepare the final design (figure 3).

Any plans that include manipulation of a waterway typically require heaps and heaps of paperwork, including grant proposal writing, applications for permits, and environmental assessments. This project was no different. Funding and resources were acquired from many different sources, such as the Arizona Water Protection Fund Commission, the Arizona Game and Fish Department, the Natural Resources Conservation Service, the City of Flagstaff, and several local private landowners.

The design and construction of Willow Wash began in 2004 and continues today. The hardscaping is finally complete and we have moved into the planting phase, our favorite part! We are choosing native flora that will be representative of Arizona's riparian habitats and that fit into the different hydrologic zones we will be highlighting (zones 2-6) in this exhibit (figure 4). Woody plant representatives will feature coyote willow (*Salix lasiolepus*) and narrowleaf cottonwood (*Populus angustifolia*), as well as many other local favorites (Table 1). A number of sedges have also been put in place around the depressional wetland. We will continue to fill in our wide open spaces this year so those of you interested in getting your hands dirty, you are cordially invited to come on out! Project completion is estimated for 2010; however, it will take a few years for the vegetation to really take hold. We expect this latest addition to our gardens will also significantly increase the bird life viewable from our grounds. Big things are happening here in Northern Arizona and we hope to see all of you flora AND fauna lovers this year at The Arboretum!

Table 1: Riparian or wetland plant species (partial list) proposed for planting in Willow Wash at The Arboretum at Flagstaff.

Common Name	**Scientific Name**
Arizona Rose	*Rosa arizonica*
Bigtooth Maple	*Acer grandidentatum*
Blue Elderberry	*Sambucus cerulea*
Boxelder	*Acer negundo*
Buttonbush	*Cephalanthus occidentalis*
Coyote Willow	*Salix exigua*
Gambel Oak	*Quercus gambelii*
Golden currant	*Ribes aureum*
Narrowleaf Cottonwood	*Populus angustifolia*
New Mexico Olive	*Forestiera neomexicana*
Quaking Aspen	*Populus tremuloides*
Red-ossier Dogwood	*Cornus stolonifera*
Siver buffaloberry	*Sheperdia argentea*
Smooth sumac	*Rhus glabra*
Westen Virgin's Bower	*Clematis ligusticifolia*

Restoring Plant Diversity in a Ponderosa Pine Forest

by Judy Springer[1], Daniel Laughlin[1,2] and Margaret M. Moore[2]

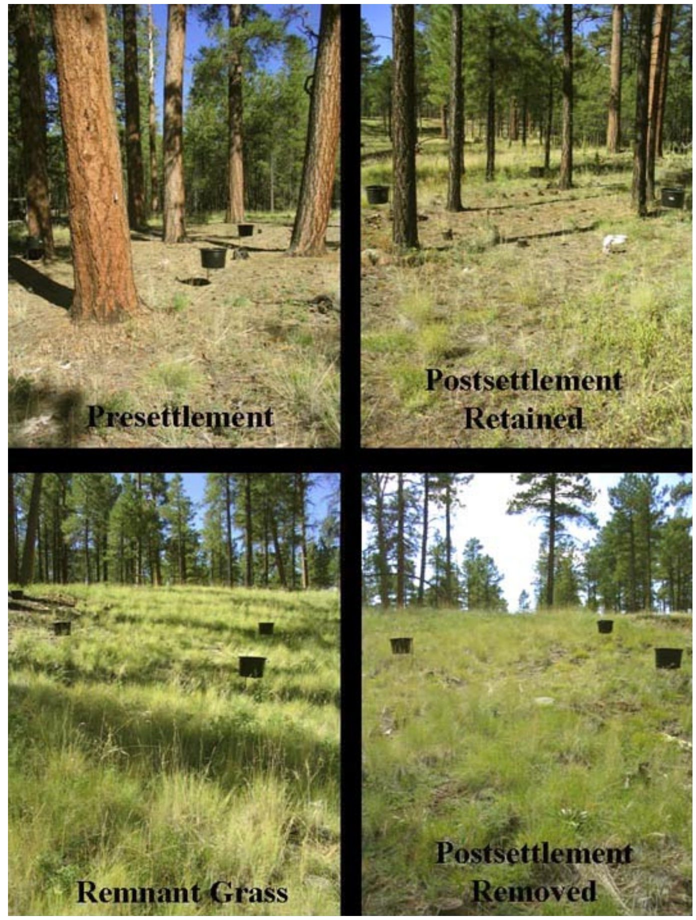

figure 1 Example photos of each patch type used in this study: (a) presettlement, (b) postsettlement retained, (c) remnant grass, and (d) postsettlement removed. Plot centers for smaller subplots are located between black buckets. *Photos courtesy Ecological Restoration Institute, Northern Arizona University. (From Laughlin and others 2006).*

Restoring the native plant community in northern Arizona ponderosa pine forests is a complex proposition for many reasons, including a lack of historical information on species composition and changes that have occurred since Euro-American settlement of the region. Numerous studies indicate that northern Arizona's pine forests are overcrowded with small trees, due in part to a suppression of natural fires. Ecological restoration treatments in these forests seek to retain old-growth trees, return fire to the system, and increase diversity of native plant species and animals. A collaboration among the USFS Coconino National Forest, Rocky Mountain Research Station, and NAU School of Forestry professors Wally Covington, Margaret Moore and Pete Fulé was initiated in 1992. An experiment was established to study the effects of ecological restoration treatments, including tree thinning and prescribed burning, on such long-term responses as decomposition rates, soil nutrient changes, tree physiology, and herbaceous plant species diversity and biomass production.

The Fort Valley Experimental Forest (originally called the Coconino Experiment Station), located in ponderosa pine forest approximately 6 miles northwest of Flagstaff near the base of the San Francisco Peaks, was established in 1908 as the first U.S. Forest Service research station. Since its establishment, a number of collaborations have flourished between the Forest Service, Northern Arizona University and the Museum of Northern Arizona. A part of that forest was designated as the G. A. Pearson Natural Area (GPNA), in honor of Gustaf Adolph Pearson, who was the first director of the Experimental Station.

For this study, fifteen plots were installed on a portion of the GPNA in 1992, and each plot was either assigned a treatment (tree thinning alone or thinning and prescribed burning, also known as a "composite" treatment) or was retained as a control. The site was intensively prepared in order to bring conditions as close as possible to those that were present prior to settlement of the region by European Americans in the late 1800s (prior to fire exclusion). Mechanical thinning treatments resulted in the removal of many trees that would, in the past, have been naturally thinned by fire. The composite treatment also involved removing the recent pine needle component of the forest floor (mostly needles, cones and other accumulated organic material on the soil surface), and then removing the remaining organic matter, known as duff, from the site before returning the pine needles to the soil surface. Harvested vegetation from a nearby prairie was then scattered across these plots to simulate a "natural" amount of fine fuels on the ground. These plots were then burned in 1994, 1998, and 2002. Additionally, each plot was stratified into one of four patch types (figure 1): Presettlement (large clumps of old-growth ponderosa pine trees), postsettlement removed (young trees thinned), postsettlement retained, or remnant grass (grassy openings).

Eighty-nine species have been recorded so far in the study area. Treatments significantly altered community composition after five years, with several native grasses and legumes driving the changes. In particular, *Astragalus rusbyi* (Rusby's milkvetch, figure 2), a Forest Service sensitive species

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figure 2 Rusby's milkvetch.

endemic to a small area near the San Francisco Peaks, was found to be more frequent and abundant in the treated units over time. *Muhlenbergia montana* (mountain muhly) was negatively affected by the repeated prescribed fires, most likely due to the late fall season burns. For the first ten years of the study, species richness (number of species per plot) did not differ significantly among the three treatments. However, eleven and twelve years after initiation of the study, more species were detected in the thinning and burning treatment than in the thinning alone or control plots. This suggests that natural disturbance processes, such as surface fire, are important for maintaining biodiversity in these forests. The increased number of species in this treatment is probably due in part to colonization of species from the soil seed bank, from off-site, or from adjacent remnant patches of vegetation.

Presettlement patches, characterized by clumps of large, old-growth ponderosa pine trees and a heavy accumulation of needle litter on the ground, showed the lowest diversity and abundance of plants prior to and after treatments were conducted. Where small diameter pine trees were removed, species richness increased to levels found in remnant grass patches. There was great year-to-year variation across treatments and patch types, especially in years of drought.

The results from this study site suggest that removing trees and applying prescribed fires increases native species richness, and also changes the composition of the plant community. Also, detectable differences may take as long as a decade to manifest in our semi-arid climate.

The composition of the plant community in ponderosa pine forests changes slowly over time. We must keep in mind that long-term monitoring of ecological studies is critical and that there may be year-to-year variation that is tied to precipitation patterns. Restoring plant species diversity and community composition to these forests is proving to be more difficult than restoring ecosystem structure, such as tree density and herbaceous biomass.

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EDUCATION AND OUTREACH COMMITTEE REPORT

by Wendy Hodgson, Education and Outreach Committee Chair and Barbara Phillips, President

Several Arizona Native Plant Society members attended the Fifth Southwest Rare Plant Conference, "Changing Landscapes in the Southwest," in Salt Lake City March 16-20, 2009. It was a time for exchanging inspiring stories of successes, and hearing glum news about some imperiled species. From the keynote address by Intermountain flora expert Noel Holmgren, to the diversity of short talks and twenty posters, there was much to learn.

The conference was extremely well-planned and went off without any evident hitch. In addition, the caterers outdid themselves with delicious nutritious food at breaks, lunches, and poster session dinner. We enjoyed renewing friendships with colleagues from all over the Southwest, met new botanists, and brought home lots of fresh ideas to enhance our abilities to study and preserve Arizona's native plants and their habitats. We hope to have a coordinated meeting of the four state native plant societies in the near future to exchange ideas about how to more effectively promote knowledge, appreciation, conservation, and restoration of native plants in the Southwest.

above Hopis tending to the restored Wepo Terrace Gardens.

above The restored Wepo Spring catchment basin.

ETHNOBOTANY: PEOPLE USING NATIVE PLANTS

Spring Restoration at Hopi

by Jessa Fisher, Flagstaff Chapter member nightbloomingcactus@yahoo.com

Water is of utmost importance to the Hopi people, often honored in ceremony and symbology. As part of their creation story goes, Hopis were given three things from their deity Ma'sau: corn, a planting stick, and a gourd of water. With these three things they were assured survival on the harsh mesas where they live, as long as they took care of the land. As a dry farming community located in the high desert of northeastern Arizona, Hopis depend on precipitation and water from natural springs and washes to water their crops of beans, corn, and squashes. In many ways and with many actions, from the spiritual to political, Hopis remain dedicated to fostering a healthy relationship with the water on their land.

The Wepo Springs and Terrace Gardens are located on the northwest side of First Mesa. There is currently a restoration project there in conjunction with the Hopi Natwani Coalition and the Center for Sustainable Environments at Northern Arizona University (NAU). The irrigation system, catchment spring, terraced fields, and fruit trees there are all receiving attention and care. With this wetland restoration, more native plants are growing than in the past.

As the Hopi say, *Paatuwaqatsi,* which means Water is Life. The spring restoration projects on their homeland are a wonderful testament to their deeply felt philosophy.

One exciting development supporting this is the restoration of natural springs out at Hopi. Two in particular have received a lot of attention and community involvement. One is the spring at the village of Hotevilla on Third Mesa, and the other is Wepo Spring near Second Mesa.

The Hopi Tribe and the Environmental Protection Agency (EPA) helped fund the Hotevilla Spring restoration. It is truly a community endeavor, with people of all ages helping out. The spring, which had not been well cared for as of late, was cleaned up through a group effort. A beautiful border around the spring was built using traditional Hopi quarried masonry and including sculptural stone art reflecting clan symbols. Phase two of the project will start soon, which includes rebuilding the staircase to the spring and strengthening the irrigated garden area.

above Hopi corn growing at the Wepo Terrace Gardens.

figure 1
Fendler's ceanothus (*Ceanothus fendleri* Gray) in flower. *Photo by A.J. Sánchez Meador.*

Ecology and Natural History of Fendler's Ceanothus *by David W. Huffman*[1]

"You can see a lot by observing" — Yogi Berra

Although forests of the semiarid Southwest are not particularly diverse in terms the number of plant species that may be found, there may be upwards of 50 or more different kinds of plants on any given acre in a ponderosa pine ecosystem. Botanical attributes of nearly all of these species have been recorded and described in various books on the flora of the region. However, even in these ecosystems with relatively few species, the ecological characteristics of most plants are only vaguely understood. In order to understand the effects species have on biotic and abiotic features and processes, and how these processes in turn affect species' populations, time, money, and effort must be invested toward careful observation and experimentation. Over the last decade, I and others at the Ecological Restoration Institute at Northern Arizona University have collected detailed data on the life history characteristics and ecological relationships of Fendler's ceanothus. The information that has come out of this work can help us better understand this species and the ponderosa pine forest ecosystem.

Fendler's ceanothus

Fendler's ceanothus (*Ceanothus fendleri* Gray) is a semi-evergreen shrub common in ponderosa pine forests from northern Mexico, east to western Texas, and north through Arizona, Utah, Colorado, and the Rocky Mountains to South Dakota. It is a relatively small shrub that typically attains no more than two or three feet in height. Leaves are alternate, grayish-green, elliptical, about 1 inch in length, minutely hairy above, and woolly beneath with prominent veins. Slender grayish stems can produce spines that can be up to one inch in length. Flowers are white, perfect, 5-parted, up to 3/16 inches in width, and borne in rounded clusters (figure 1). Fendler's ceanothus blooms from April through October, but typically reaches its peak flowering in mid June to July. Fruit is a capsule that turns a reddish brown as it matures. Mature seeds are a chocolate brown and typically about 1/10 inch in diameter. As capsules dry in late summer and crack open, seeds are forcibly ejected. Once dispersed, these hard-coated seeds may lie dormant in the soil for many years.

Ceanothus is in the Rhamnaceae (Buckthorn) family, which is represented in Arizona by other woody plants in *Frangula*, *Rhamnus*, and *Ziziphus* genera. The USDA PLANTS database (**www.plants.usda.gov**) describes 65 species of *Ceanothus*, all of which are North American, and most are found in the western United States. Fendler's ceanothus is classified in the section *Euceanothus* of the *Ceanothus* genus. This is the more ancient of the two recognized sections (the other being *Cerastes*) and includes species such as *C. velutinus*, *C. intergerrimus*, and *C.*

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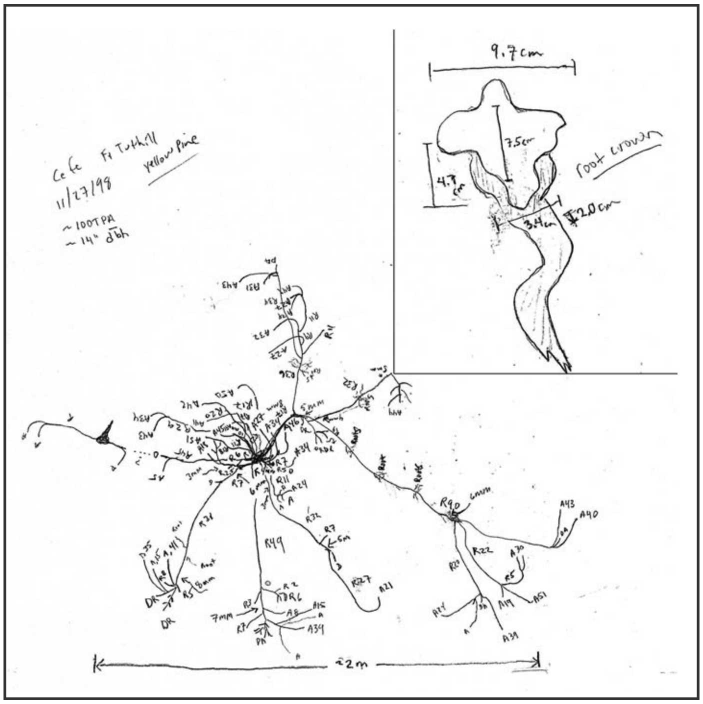

figure 2 Sketch of the belowground structure of Fendler's ceanothus (main box; Huffman unpublished). Aboveground stems, indicated with an "A" in the sketch (along with stem height in cm; e.g., A43 =aboveground stem of 43 cm in height) arise from belowground horizontal branches, indicated with an "R" in the sketch (along with branch segment length in cm; e.g., R22) or directly from root crowns. Root crowns (upper right box) are persistent structures that produce resprouts after disturbance and have tap roots that anchor the plant. Close examination of root crown cross-sections have indicated up to 30 growth rings on an individual sample; however, longevity of individual plants is unknown.

figure 3 Fendler's ceanothus utilizes a dual regeneration strategy in response to disturbance. After low severity fire, plants resprout from buds on root crowns and belowground branches (upper photograph). More intense fires that transfer greater levels of heat to soils can stimulate dormant seeds to germinate (lower photograph). Fires that smolder in deeper forest floor layers have potential to kill both established plants and dormant seeds *Photos by D.W. Huffman.*

Ecology and Natural History of Fendler's Ceanothus *continued*

sanguineus. Other species of Ceanothus found in Arizona include *C. greggii*, *C. integerrimus*, and *C. martinii*.

In addition to its importance in native, wild ecosystems, Fendler's ceanothus makes an attractive addition to home gardens and parks. Other common names for this plant include buckbrush, deer brier, deerbrush, and mountain lilac.

Plant Traits

Fendler's ceanothus is a relatively long-lived shrub that is often found growing as diffuse patches of aboveground stems. Patch sizes may reach six feet in diameter, and stem density within patches may be as high as 10 stems per square foot. Stems often appear to grow singly or in small, attached groups, arising directly from the soil surface. Younger stems are supple and grayish green with a felty surface. As stems age, bases become yellowish and waxy, and bases are woody and on the oldest stems and may be furrowed with reddish-black coloration. Excavations have indicated that such patches are commonly formed of stems that originate from horizontal, belowground branches or from persistent root crowns (figure 2). Root crowns are plant anchor points that produce deep tap roots as well as these belowground branches and aboveground stems. Although maximum longevity of plants is unknown, examination of a limited number of root crown cross-sections has indicated up to 30 or more growth rings on individual samples.

Like other *Ceanothus* species, Fendler's ceanothus forms a symbiotic relationship with *Frankia*, a type of bacteria that is capable of fixing atmospheric nitrogen (N_2) into a plant-usable form (NH_4+). *Frankia* infects *Ceanothus* roots and stimulates the formation of root nodules within which nitrogen fixation takes place. Fendler's ceanothus plants can fix around 0.1 lb of N per acre per year. This N is used for plant growth and development but can be released into the soil when the plant dies or sheds leaves. In this way, Fendler's ceanothus contributes to the nitrogen budget of the forest ecosystem.

Regeneration

To persist in forest plant communities, Fendler's ceanothus employs multiple life history strategies, including long-lived plants, resprouting from belowground buds, and seed dormancy. In particular, this species appears well adapted to the frequent-fire disturbance regimes that characterized the evolutionary environment of species associated with ponderosa pine forest ecosystems. After low-intensity fire, Fendler's ceanothus resprouts from belowground branches and root crowns (see Figure 3). These new stems are commonly long (up to about 50 cm) and unbranched. Long stems produced after fires allow this species to rapidly regain pre-disturbance size and competitive stature. Fires that burn hotter, of course, can result in plant death. However, these more intense fires often stimulate germination of dormant seeds residing in the soil seed bank (figure 3). Heat from fire allows seed coats to open, which in turn facilitates absorption of water and oxygen and begins the germination process. Laboratory tests with locally collected seeds showed the highest germination rates for seeds heated to around 194° F (90° C); cooler heat treatments produced significant less

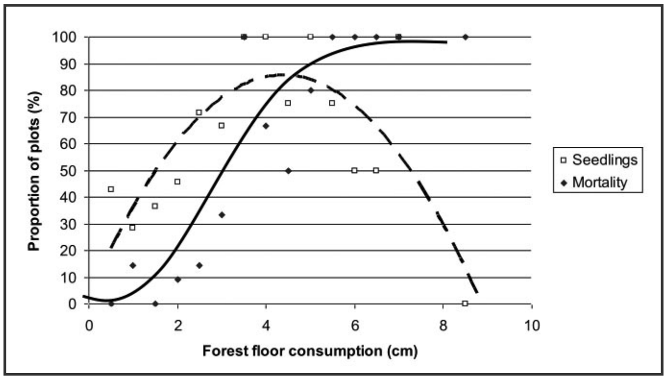

figure 4 Chart showing effects of fire severity on Fendler's ceanothus population characteristics. As the depth of consumed forest floor increases, more heat is transferred to soils. At low levels of forest floor consumption, a smaller proportion of study plots showed adult plant mortality (solid line); these plants survived and resprouted. Similarly, fewer plots showed seedling emergence (dashed line) at low levels of forest floor consumption; too little heat was transferred to soil seed banks to stimulate germination. At highest levels of forest floor consumption, all adult plants are killed along with seeds in the seed bank (from Huffman 2003).

germination, whereas higher heat levels tended to kill seeds. Similarly, in field experiments that tested effects of prescribed fire on population responses, seedling emergence was highest on plots showing moderate amounts (about 1.5 inches) of forest floor consumed by the fires (in this experiment, forest floor consumption was a surrogate measure for heat transferred to soil). Emergence was relatively low on plots that burned less completely as well as on those that showed greater levels of forest floor consumption. Thus, in disturbance-free periods, long-lived stems and persistent root crowns allow Fendler's ceanothus plants to survive in forest understories. In the event of a disturbance such as fire, Fendler's ceanothus can resprout, recruit seedlings from a dormant seed bank, or both (figure 4). In very intense fires, (i.e., those that transfer high levels of heat to forest soils), both adult plants and dormant seeds may be killed.

Ecological Relationships

In many ecosystems, due to higher levels of crude protein in leaves, stems, and other parts, nitrogen fixing plants are important forage resources for herbivores. Ponderosa pine forests are no exception, and Fendler's ceanothus is keenly sought after by animals such as mule deer, Rocky Mountain elk, porcupine, and rabbits (figure 5). For example, in field experiments that examined responses of Fendler's ceanothus plants to tree thinning associated with forest restoration treatments, 44-69% of all new branches produced were browsed over a two-year period. This level of herbivory resulted in potential growth reduction of 79-92%, as compared with plants that were protected by wire cages. This research indicated that in areas where forests are thinned, thus creating an environment attractive to large herbivores for foraging, persistence and growth of Fendler's ceanothus populations may be severely constrained by browsing. This may present a conundrum of sorts for forest managers concerned with improving habitat for animals such as deer and elk. To improve habitat in these cases, use of forage resources may need to be deferred or modified.

Intense herbivory on Fendler's ceanothus can lead to reduced flower and fruit production. This may be due to a number of reasons: 1) heavily browsed plants may not have adequate resources (e.g., carbohydrate stores) to produce flowers; 2) incipient flower buds may be removed by browsers; and 3) plants may produce flowers, just to have them soon eaten. In addition to affecting potential reproduction, such intense herbivory can have effects that propagate through the ecosystem. For example, laboratory studies have shown that up to 70% of seeds collected from Fendler's ceanothus plants may be infested by a parasitic wasp (*Eurytoma squamosa*). These tiny wasps lay their eggs on very young ceanothus seeds and, as the seeds grow, the young wasps develop. As larvae, the wasps consume the internal seed tissues; larvae then pupate and metamorphose into adults; the adults then chew their way out of the seed, fly away, and start the process all over again (see figure 5). Interestingly, this particular wasp has very close ties with Fendler's ceanothus and is not known to parasitize seeds of any other plant species in Arizona ponderosa pine forests. Further investigations of ceanothus seed usage have indicated that up to 24% of the seeds produced in a year may be consumed by other seed eaters, particularly birds

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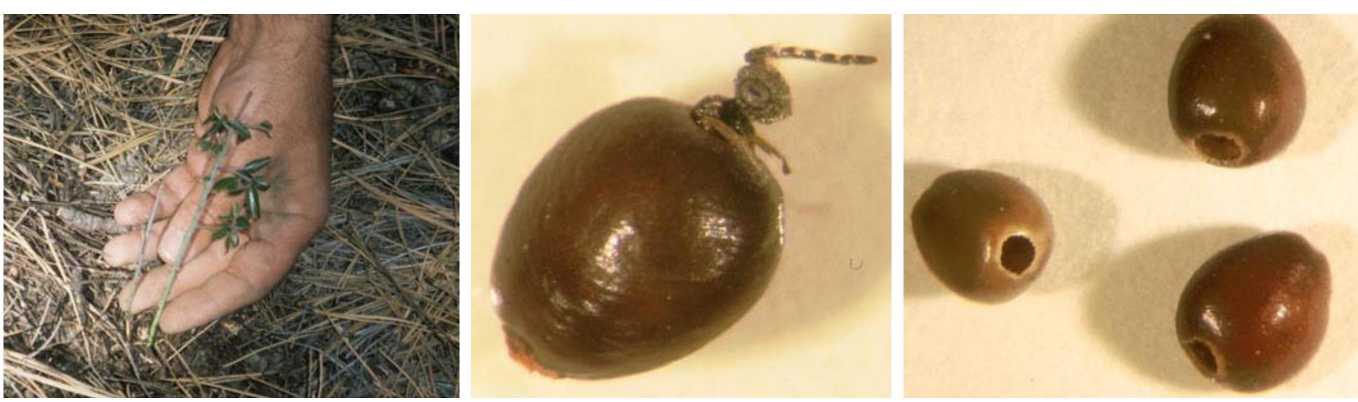

figure 5 Fendler's ceanothus is highly sought after by both vertebrate and invertebrate herbivores. Images here show browsed Fendler's ceanothus stems (left), an emerging seed parasite (center), and characteristic emergence holes from seed parasites (right). *Photos by D.W. Huffman.*

Riparian Restoration in the Yuma Area

by Karen Reichhardt[1]

above Migratory birds documented by Reclamation biologists at the Pratt agricultural lease tree nursery.

When I first started working along the Lower Colorado River in 1990, the general consensus among biologists was the river was dying a slow death. Dams and water delivery systems had starved the river of its once prolific floods that replenished riparian habitats. Riparian restoration projects faced many challenges including the lack of water in the floodplain, salinity, lack of plant materials, competition from invasive plants, and, of course, funding. Early projects often focused on mitigating dry sandy deposits of dredged spoil using drip irrigation or cottonwood and willow pole plantings with mixed success.

A lot of water has gone under the bridge in the past 20 years. Riparian restoration in the Yuma area is now transforming the river's edge. The City of Yuma, Yuma Crossing National Heritage Area, Bureau of Reclamation, Bureau of Land Management, Imperial and Cibola Wildlife Refuges and the Cocopah and Quechan Tribes and Arizona Game and Fish Department all have ongoing restoration projects. Biologists have learned to artificially create the floods so necessary to the viability of this habitat.

The farming model plants agricultural fields along the river with riparian trees and then flood irrigates. This requires water rights, water delivery features such as irrigation ditches and pumps, and farming equipment. Riparian habitat covered by pure saltcedar stands can be converted into agricultural fields and salt tolerant crops are planted until the soils are suitable for cottonwood and willow trees or mesquite. In 1999, Bureau of Reclamation used this agricultural model and successfully planted 12 acres of cottonwood and willow trees in an agricultural field at the BLM Pratt agricultural lease. During the first years after planting, Bureau of Reclamation regularly flood irrigated the trees to create flood-like conditions. The dense plantings from one-gallon pots, seeds, or limb cuttings placed diagonally on a furrow out-competed saltcedar seedlings to form a dense canopy of trees that attract migratory birds.

Another model to create flood conditions suitable for riparian habitat creates a natural flooded channel by excavating side channels of the Colorado River. The Yuma East Wetlands, funded by the Yuma Crossing National Heritage Area and designed by Fred Phillips Consulting and Tom Moody of Natural Channel Design, was once a saltcedar and giant reed forest so dense it was an impenetrable black sterile thicket. The genius of this park's design was to bulldoze the existing decadent vegetation and reshape the floodplain by using stop log structures on either end of an excavated channel to back up naturally flowing water and raise the water elevation to simulate flooding the banks. Decant water from the City of Yuma water treatment plant is also fed into a permeable ditch that seeps into a wetland composed of saltgrass and mesquite.

The City of Yuma Parks and Recreation created The Yuma West Wetlands on what was once an old city dump bordering the Colorado River. The area was capped with soil and now hosts a boat launching site, trails, tree groves, a hummingbird garden, pond, children's climbing gym (the largest of its kind), and burrowing owl recovery habitat bordered by a strand of lush thick wetland and riparian vegetation. The gazebos around the park are always occupied by large and small groups of people.

[1]Bureau of Land Management, Yuma, Arizona

above Bird netting within the Pratt agricultural lease tree nursery in 2003.

Cibola and Imperial Wildlife Refuges, Arizona Game and Fish Department and BLM have been planting cottonwood and willow in agricultural fields or converted floodplain to attract migratory birds. Bureau of Reclamation is purchasing agricultural land in the Parker area and has developed large acreages of southwestern willow flycatcher habitat for the Lower Colorado River Multi-Species Conservation Plan.

The river may never return to mighty spring floods and vast riparian floodplains. However, biologists are no longer discussing the demise of riparian habitat, but looking with optimism to the potential still possible using resources available.

Restoration projects on the Lower Colorado River will be interesting to watch over time to see how they compare to unrestored riparian habitat. Factors to consider are cost, maintenance requirements, habitat value, and social value, to name a few. In the mean time, if you haven't visited Yuma recently, you will be delighted to see the changing riparian landscape. A mighty floodplain is still at the source of some desert river jewels.

Ecology and Natural History of Fendler's Ceanothus *continued from page 13*

and rodents. Finally, a study that sampled entire invertebrate assemblages over three years on Fendler's ceanothus showed that 65 different families from 13 invertebrate orders were represented. In this study, browsed plants showed dramatically reduced numbers of insect individuals, numbers of different insect families, and complexity of the insect assemblage (i.e., representation of insect guilds such as herbivores, predators, scavengers, etc.) compared with plants that had been experimentally protected from deer and elk. These above studies, when taken together, indicate the importance of Fendler's ceanothus to various organisms in the ponderosa pine ecosystem and also suggest that resources associated with this plant species can be significantly reduced for ecosystem food webs by intensive herbivory.

Lessons in our own backyard

Conservation of native biodiversity begins by taking stock of the resident taxa in our ecosystems and, of course, developing an appreciation for their individual characteristics. More work is needed to identify and describe ecological characteristics of many species, particularly those of native plants. Information concerning life history traits, responses to disturbance, and relationships with other organisms is critically important in developing intelligent land management approaches. Such information calls for careful and detailed observation and experimentation.

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Using a Diverse Seed Mix to Establish Native Plants on a Sonoran Desert Burn

by Judy Springer[1] and Scott Abella[2]

figure 1 A burned and unseeded area in Cave Creek Regional Park, November 2005. Photo courtesy of John Gunn.

Historically, seeds of both native and non-native species were often applied to the landscape following wildfires in an effort to prevent erosion or to improve availability of food sources for domestic livestock or wildlife. The contemporary trend among managers of public lands in the West is to seed with native species to obtain an increase in diversity and to improve wildlife habitat. The success of any seeding project in Arizona is dependent on a little bit of luck and on precipitation that falls at the proper intervals to ensure survival of seedlings. Even with good precipitation, however, many factors can conspire to prevent seedling establishment, including seed predation by birds or rodents, or the use of plant stock that is not adapted to the area in which it is applied.

Unlike many ecosystems in the West that evolved with fire, the Sonoran Desert is not thought to have burned frequently or on a regular basis. Like many desert ecosystems, however, the Sonoran has been invaded by non-native annual grasses that ignite readily and provide an almost continuous source of fuel on the ground when a fire is started. Attempting to restore the native plant community in these ecosystems can be very challenging. The use of native species has been limited by a lack of available seed and by findings that native desert species are often difficult to establish.

Following a June 2005 human-caused wildfire in the Cave Creek Regional Park north of Phoenix, land managers at the park teamed up with researchers from the Ecological Restoration Institute at Northern Arizona University in Flagstaff to monitor the success of a seeding project. The park is in the Arizona Upland Subdivision of the Sonoran Desert and is populated by a diverse plant community that includes many species of cacti, including giant saguaro (*Carnegiea gigantea*), various small trees such as foothill palo verde (*Parkinsonia* (*Cercidium*) *microphyllum*), shrubs such as creosote bush *(Larrea tridentata),* and a number of native and non-native annual and perennial grasses and wildflowers. The site was seeded with a combination of slurry and mulch that included seeds of 28 commercially available species native to the site. By assigning a monetary value to large perennial plants (e.g., cacti, shrubs) killed on park land by the fire, an insurance settlement provided funding for the seeding.

A team of researchers and land managers — including John Gunn, Spur Cross Ranch Supervisor and the lead on the seeding project — collected data at the site five times over an approximately three year period from fall 2005 until spring 2008 (Figures 1 and 2). Species exhibited several different establishment patterns through time on the burn. Some species, such as several of the seeded grasses including tanglehead (*Heteropogon contortus*) and curly-mesquite (*Hilaria belangeri*), had emerged by the first fall, but plants did not exhibit long-term survival. Only one grass, purple threeawn (*Aristida purpurea*), exhibited substantial establishment by the end of the study.

Other species (e.g., creosote bush) were rarely observed, although it is possible that seedlings emerged and died between monitoring dates. No seeded shrubs became well established. The perennial Beardtongue species (*Penstemon eatonii* and *P. parryi*) exhibited an episodic emergence pattern, where seedlings were recorded the first spring after seeding, subsequently disappeared, were recorded again during the second spring, then were absent during the third spring (Figure 3). Another category of species, exemplified by the perennial desert senna (*Senna covesii*) and the annual desert bluebells (*Phacelia crenulata*), became established early on and were recorded throughout the monitoring period.

We consider desert senna to be the most successful species in this study. In addition to occupying nearly 60% of plots in all five sampling times, it exhibited the highest relative cover of any seeded species. By two years after seeding, it had attained

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figure 2 Researchers collect data in seeded plots, March 2008. Photo courtesy of Mark Daniels.

a density of approximately 2000 plants/ha (810 plants/acre). Several other seeded forbs exhibited establishment more episodic than desert senna, but still successful during multiple monitoring periods. These species include Gordon's bladderpod (*Lesquerella gordonii*), California poppy (*Eschscholzia californica*), Coulter's lupine (*Lupinus sparsiflorus*), and exserted Indian paintbrush (*Castilleja exserta*).

As of the last monitoring date, composition of non-seeded species was generally similar on the seeded and a nearby unseeded burn area. Native annuals such as curvenut combseed (*Pectocarya recurvata*) and desert Indianwheat (*Plantago ovata*) occurred at high frequencies in both areas. Although exotics were present on the seeded area, the suite of treatments (mulching, seeding, and fertilization) did not increase frequencies above those on the untreated burn. Nevertheless, there is concern that abundance of Mediterranean grass (*Schismus barbatus*) and red brome (*Bromus rubens*) will increase, thereby accumulating fuel, and possibly competing with native plants.

Although only seven (25%) of the 28 seeded species became established in 25% or more of plots by the end of the monitoring period, the site appeared well vegetated and contained flowering individuals. This aesthetic component, and the avoidance of barren land that may encourage illegal dumping or other abuses, is a positive outcome of this seeding project for park management. Two years after seeding, seeded species comprised 54% of the species per plot, on average, and 29% of species per plot after three years. Long-term success of the seeding depends on the ability of seeded species to persist above ground or in the soil seed bank, or to facilitate the establishment of other native species.

Seeding has often been largely discouraged as an option for revegetation of native species in North American warm deserts, but this area of research begs further study. Our data suggest that seeding native species may have potential as a revegetation tool in these deserts. Our viewpoint is that in evaluating seeding as an option, we need a better understanding of which species are amenable to seeding given current technology, which treatments can promote success, and under which environmental site conditions particular combinations of seeding components can be effective. Full results of this research are expected to be published in an upcoming issue of *The Native Plants Journal.*

figure 3 *Penstemon parryi*, a native species in the seed mix, shows off its colors in March 2008. Photo courtesy of Mark Daniels.

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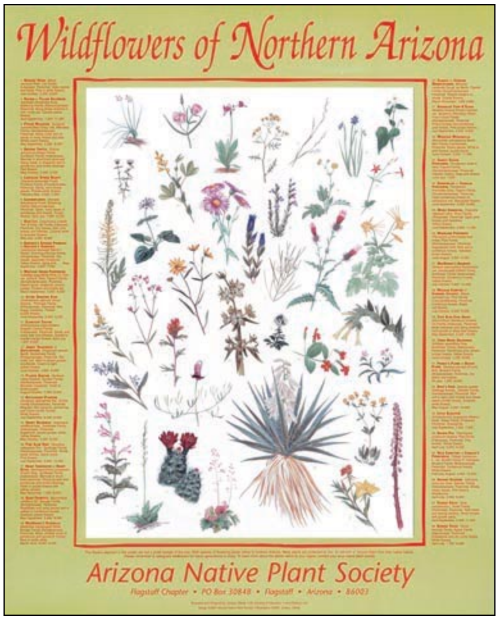

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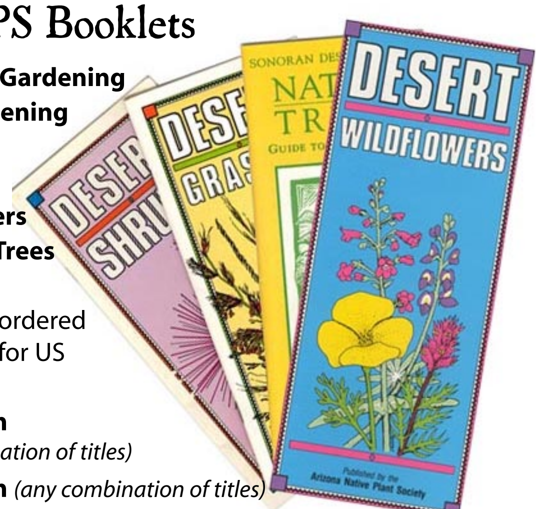

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