Lingua Botanica

The National Newsletter for FS Botanists & Plant Ecologists

Can you smell it? I sure can: earthy and primal. No, it's not the honey scent of spring witch hazel, nor is it sweet rhododendron or pungent lomatium. I'm pretty sure that distinctive smell is the scent of change. You know the smell. Its hard to tell if its sweet or sour, but isn't it enticing? Change isn't necessarily easy or fun. My good friend Larry Stritch is no longer the National Botany Program Leader. I'm going to miss his thoughtful guidance, but I'm happy for him. He's got a new gig that he's enjoying and that's a good thing. Change can be good for you. Things in the Forest Service seem to be poised for change, but take it from me, its not going to be the regressive change that some people are whispering about. Change is an opportunity. This year we decided we wouldn't plant bell peppers. Goodness knows we love them; they're so crisp, yummy and colorful. But we needed space for an expanded herb garden. We are going to miss those peppers. We'll miss them on pizza, we'll miss them in veggie lasagna, and we'll miss them in stir-fry. But we're going to love the new taste possibilities like lime basil. Change tastes great. It's been especially difficult for me to find my favorite beer (Black Butte Porter) in Atlanta lately. You know how annoying that can be. But then again I've quaffed several new brews this winter. Some have been skunky, but I'm enjoying the dickens out of a new local nut-brown ale. Change can get you buzzed. Yeah, change can be tough and change can even require a period of adjustment. Dealing with change can slow you down while you are learning new ways to get things done, but goodness gracious, change is liberating. There is not a single person reading this that enjoys every aspect of their job. Being a botanist is GREAT, but the BE process, Forest Plan revision, and answering appeals is rarely entertaining (even for the most twisted among us). Now is not the time for discontent, now is the time to seize an opportunity. It shouldn't be difficult; they're all around us. the editor.

In this Issue

Vol. 3, Issue 1 2002

CELEBRATING AMERICA'S WILDFLOWERS

Useful URLs

Celebrating Wildflowers! 2002 Calendar of Events:
http://www.nps.gov/plants/cw/events.htm

Celebrating Wildflowers Video: A couple years ago, Home and Garden Television (HGTV), in cooperation with many of our Wildflower Partners, put together a beautiful television program on wildflowers. HGTV will air this program in May 2002, or you can own a videotape copy for your Forest or District.
http://www.hgtv.com/HGTV/project/0,1158,GALA_project_15216,FF.html
http://www.hgtv.com/HGTV/store/videoDetails/0,1267,801,FF.html
USDA Forest Service does not endorse HGTV, but botanists and friends will love this program…

Native Plant Information Network: A product of the Lady Bird Johnson Wildflower Center, this growing portal has a lot to offer
http://www.wildflower.org/npin/index.html

Terry Ball's Phytolith Page: See scads of groovin' electron-micrographs of these interesting grass artifacts at Terry's page.
http://home.byu.net/~tbb/tball/index2.html

Biological Soil Crusts: Didn't we used to call this cryptogamic crust? Or was is cryptobiotic crust? Or microbiotic crusts? What ever you called it, Soilcrust.org is a great resource for the novice and sophisticated crustophile. The image and reference pages are especially good, but this site also has great down-loadables to share with your unconverted friends. I've really taken a "lichen" to this website…
http://www.soilcrust.org/

National Agriculture Library - Digital Desktop Library: Scads of e-journals!
http://www.nal.usda.gov/usda/elist.htm

Celebrating Wildflowers Events Around the Country

Its spring again (woo hoo) and botanists around the country are investing their time to lead an anxious laity on adventures of discovery of the wildflower kind. Thanks to you, little boys and girls will learn funny plant tricks (like exploding *Impatiens* capsules), grandparents will tell stories to new ears, and couples young and old will make a date to enjoy a romantic little walk to look at forest flowers. It could be a walk with Ann DeBolt and Edna Vizgirdas in the Boise Foothills, an old-growth hike with Linda Parker up on the Chiq-Nicolet, Zoo Day with the whole family in Portland, or tripping with a hundred kiddies learning their first plant names in the hills around Salmon, Idaho. If you aren't sure where you're going to go on your wildflower walks this spring, check out the Celebrating Wildflowers Calendar of Events at http://www.nps.gov/plants/cw/events.htm. **If you're hosting an event, post it on the Calendar at plant@plantconservation.org or http://www.nps.gov/plants/cw/submitev.htm. Everyone wants to know!**

Karl Urban Celebrating Wildflowers Award Winner for 2002
Julie Kierstead Nelson – Shasta-Trinity National Forest

The Karl Urban Award is given annually by the Forest Service and the Bureau of Land Management to the person that exemplifies dedication to the floral resources, through creativity, community involvement, volunteer programs, and educational efforts such as wildflower walks, talks, festivals or classes. **This year's winner is Julie Kierstead Nelson, the Forest Botanist for the Shasta-Trinity National Forest** in northern California. We are very happy for Julie and proud of her efforts and many accomplishments. *Lingua Botanica* is pleased to reprint the nomination letters of all Karl Urban Award winners in the hope that they will inspire others to excel.

Based on a life-long love of all flowers, Julie Kierstead Nelson has made lasting contributions to the conservation of western native plants. Through her career to date as a professional botanist, and in her generous personal efforts, the scope and significance of her contributions ranges from on-going regional programs, strengthened partnerships and state laws, and increased public awareness of the importance and beauty of rare and native plants. In her roles at the Berry Botanic Garden in Portland, Oregon, and the Shasta-Trinity National Forest in northern California, Julie has melded her commitment to the science of rare plant conservation, her creative vision and leadership, and her eloquent, compelling and personable style for the benefit of botanical resources. She has also contributed her personal passions and skills to the educational efforts of the California Native Plant Society and local elementary schools.

The following examples of Julie's dedication to celebrating wildflowers demonstrate the scope and significance of her contributions to native flora of North America over the past 20 years.

First Curator of the Berry Botanic Garden Seed Bank for Rare and Endangered Plants of the Pacific Northwest (Portland, Oregon. 1983-1989). Julie pioneered the first seed bank in the United States developed with the explicit purpose of conserving the rare flora of an entire region (Oregon, Washington, Idaho and northern California). The collections serve as genetic insurance in case of species or population extirpation, and provide the potential for reintroduction with plants genetically representative of the species natural diversity. In addition to establishing technical procedures and standards, Julie set the basic philosophy of the Seed Bank as one of a support role and resource for primary in-situ conservation management - a significant shift in the dominant paradigm of seed banks at that time. As a creative collaborator Julie enlisted regional conservation organizations, regulatory and land management agencies, and volunteers for the program. As a result, the Seed Bank now maintains samples of over 250 rare and endangered plant taxa as a member of The Center for Plant Conservation. (Contact: Dr Edward O. Guerrant Jr., Conservation Director, Berry Botanic Garden, Portland, Oregon. (503) 636-4112)

Conservation project for *Penstemon barrettiae* with Bonneville Power Administration. *Penstemon barrettiae,* Barrett's beardtongue, is endemic to cliffs and rock outcrops in the Columbia River Gorge of Oregon and Washington. Now state-listed as Threatened in Washington, the species is restricted to localized spots, including the Bonneville Dam area. A significant population of the Penstemon was in danger of extirpation when new locks were to be built in the late 1980s. While at the Berry Botanic Garden, Julie worked with the BPA to collect cuttings of the individual plants (personally going up in a "cherry picker" to retrieve the plants from the steep cliff face, whereupon equipment failure required her to climb out of the basket into another cherry picker at 50 feet up the cliff side. Dedication and commitment at its highest). The botanic garden propagated the cuttings and planted them back at the site after the locks were put in, genetically recreating the extirpated population. Julie developed an educational display on the species' recovery, the story was featured in the national Audobon magazine, and she received the national Chevron Conservation Award for her work. (Contact: Dr R. Linda McMahan, former Executive Director of the Berry Botanic Garden. Currently Yamhill County Extension Office, Oregon State University, McMinnville, OR. (503) 434-8910)

Worked on the establishment of the Oregon Endangered Species Act (Oregon Senate Bill 533, ORS 564.100). During the mid 1980s Julie worked with state legislator Vera Katz (now mayor of Portland, OR) and many agencies, individuals and organizations, hosting public forums and developing the information needed for the 1987 passing of the bill. Her perseverance was instrumental in passing the bill that provided new protection of the State's rare plant species, and mandated responsibility for threatened and endangered plants to the Oregon Department of Agriculture. The Oregon Endangered Species Act directs the ODA to maintain a strong program to conserve and protect native plant species threatened with extinction. (Contact: Bob Meinke, Program Director, Oregon Natural Resources Division Plant Conservation Biology Program. Salem, OR. (503) 986-4716)

Botany Program Manager for the Shasta-Trinity National Forest (1989 to present). As the Forest Botanist on the Shasta-Trinity National Forest for the past 13 years Julie has developed a full program with emphasis and accomplishments in the management of Sensitive plants, noxious weeds, ecological classification, Botanical Special Interest Areas, and Research Natural Areas. In recent years she has contributed her talents to the development and implementation of the inter-agency Northwest Forest Plan. In 1993 Julie participated in the initial development of the Survey and Manage vascular plant list, and in 2001 she was selected as the Regional representative on the fungi taxa team. Julie persevered during the Shasta-Trinity National Forest's land management planning process in the early 1990s, successfully incorporating management guidelines for Sensitive plant species, and facilitating the establishment of nine Botanical Special Interest Areas on the Forest. Her strong ethic for partnerships has led to joint administrative studies with Sierra Pacific Industries (SPI), a northern California timber and resource management company. With partnership grant funds the Forest and SPI have jointly undertaken inventories and management studies for Sensitive plant species *Phacelia dalesiana*, and currently a suite of rare serpentine endemic species found on both public and SPI lands. (Contact: Jim Harvey, Ecosystems Management Officer, Shasta-Trinity National Forest, Redding, CA. (530) 242- 2206)

Celebrating Wildflowers Program. Julie has been the Region 5 Celebrating Wildflowers Coordinator for the last two years. Currently she has taken the lead to develop a regional website that will include information on celebrating wildflower events on national forests around California.

Julie authored sections of *California's Wild Gardens*, *a Living Legacy,* a book published by the California Native Plant Society for the State of California in association with the California Academy of Sciences in 1997. This stunning volume showcases the wonderful diversity of the California flora and introduces the public to wildflower "hotspots" around the state that are home to rare and endemic plants. Julie's contribution highlighted two spectacular wildflower areas on the Shasta-Trinity National Forest.

Recent environmental ed activities for Julie include wildflower and noxious weed programs for the Monarch Learning Center, the Turtle Bay Museum and Arboretum, and a community native plant propagation workshop at the Redding Arboretum. She has also opened her home to several hundred people from the Redding community to illustrate fire-safe landscaping with native species and compatible garden plants.

Julie has contributed to our knowledge of the California flora by mounting and donating 1000 specimens the herbaria at Oregon State University and the University of California Berkeley. She has also donated numerous photos to the online "CalPhoto" database. This resource used by thousands of Californians with a need for photos of native plants. The users range from school children to academic researchers.

Julie enjoys an artistic talent as a botanical illustrator. In 1999 she donated nine colorized line drawings of northern California wildflowers to the Shasta Chapter of the California Native Plant Society (CNPS) and coordinated the production of a set of wildflower greeting cards. The CNPS chapter used the profits for college scholarships and a fund for teaching materials. One of her drawings was also donated for use in the publicity poster for the annual Siskiyou County Wildflower Show in 1999. Julie has also donated plants propagated at her home nursery to the annual CNPS native plant sale in Redding, California (Contact: Tom Engstrom, California Native Plant Society. (530) 378-8000)

"Illustrated Field Guide to Selected Rare Plants of Northern California" (Gary Nakamura and Julie Kierstead Nelson, editors. University of California Agriculture & Natural Resources Publication 3395. 2001). In the mid 1990s Julie Nelson, and other Forest Service botanists saw an opportunity for coordination and cooperation between the botanists with the BLM, the FWS and other federal and state agencies, as well as non-agency professional botanists and the California Native Plant Society. An ad hoc working group of Northern California Botanists (NBOT) began meeting quarterly in Redding, CA to jointly address mutual issues of rare plant conservation and management. Serving as NBOT's de facto chair, Julie recently facilitated the development of a 370-page color field guide to 149 rare plant species from the ten northernmost counties in California.

Coordinating the information from two decades of the group's fieldwork and professional knowledge, Julie served as the technical editor of the publication, and enlisted Gary Nakamura of the University of California Cooperative Extension Service to coordinate the publishing aspect of the project. The editing required compiling contributions from 29 authors, 80 photographers, 26 sources for illustrations, 11 tables, and 150 maps, taking over two years. Julie's vision and persistent efforts were the driving energy behind the creation of this book, which is now used by professional botanists, consultants, educators and wildflower enthusiasts to be able to recognize and protect the rarest plants of Northern California. (Contact: Gary Nakamura, University of California Cooperative Extension, Redding, CA. (530) 224-4902. http://anrcatalog.ucdavis.edu/merchant.ihtml?pid=5395&lastcatid=87&step=4)

Coordination with the BLM. The Shasta-Trinity NF and the Redding BLM office jointly host the quarterly NBOT meetings. Lands of the Shasta-Trinity and the BLM are intermixed, and the agencies coordinate efforts to manage sensitive species and to comply with the vascular and non-vascular plant survey and manage direction that is part of the Northwest Forest Plan. Julie assists the BLM with plant ID's and use of the Forest herbarium

In summary, Julie Kierstead Nelson lives her life Celebrating Wildflowers - and does so in a way that instills inspiration and respect in those that work with and around her. This nomination is submitted with the intent of honoring Julie's dedication to the conservation, appreciation and love of our native flora that she demonstrates through the avenues of on-the-ground conservation, seed banking, legislation, publication, partnership building, grants, education, botanical illustration, and good old fashioned gardening. Julie's life is itself an elegant illustration of one of her favorite mottos, "I've never met a flower I didn't love".

Real Splitters Don't Eat Quiche!
Why we Love Larry Stritch.

Larry Stritch isn't the National Botany and Rare Plants Program Leader anymore, but I'm really glad he remains involved in the Forest Service botany program. Larry came to the Forest Service in 1989, after serving for three and a half years as the botanist for the Illinois Natural Heritage Program. He became the Forest Botanist for the Shawnee NF, and as such was the first Forest Botanist in the Eastern Region. After just over three years, Larry assumed the mantle of Regional Botanist for R9. From there, he took a seminal role in the conversion of Joliet Army Arsenal to Midewin National Tallgrass Prairie, a project he describes as his "proudest accomplishment." Where do you go from helping to establish the nation's first national tallgrass prairie? Larry went to the Washington Office. In 1998, Larry became the Forest Service's second national botany program leader.

Those that have known Larry for much longer than me have told me many funny and interesting stories about him. Most of these tales have highlighted his intelligence, quick wit, and wry sense of humor. For instance, as a doctoral student of Robert Mohlenbrock (Southern Illinois University), Larry did a revision of the genus *Wisteria*. One of his findings was that there were enough differences in New World and Old World members of the genus to segregate them into separate genera. The Old world species were put into *Rehsonia*. The inevitable accusations of "splitter" were made. You know how taxonomists are. If he had retained a single genus, they'd have called him "lumper."

A few years later at the Natural Areas Association conference in Potosi, Missouri, several of the Mohlenbrock students attended the banquet and, of course, sat at the same table with Larry. One of the selected items for dinner was a quiche of some description. At one point before being served, Larry mentioned that he didn't care for quiche. Upon hearing this, a friend commented that, **"Real splitters don't eat quiche!"** There were immediate roars of laughter, and Larry sat with a grin, tapping his fingers trying very hard not to bust out laughing hysterically himself.

People that knew Larry at work considered him a risk-taker and an innovator. Sometimes he was criticized, but would later be praised for his successes. When he was in R9, he would come to have the respect of DNR biologists and Firster's alike. In the Washington Office, he left an indelible mark on the national botany program by leading the development of the national botany strategy (which lead to the creation of *Lingua Botanica*!). Larry could have had a bright academic career, but he chose to apply his considerable skills to the management realm of ecological botany. The result has been dozens of natural areas attributable to his ambition, large tracts of tallgrass prairie at the center of the Forest Service's crown of eco-treasures, a cadre of Eastern Region botanists that owe the opportunities they've had to thrive and make a difference to a guy that was willing to reach beyond his grasp, and a new sense of direction for Forest Service Botany. Not too shabby.

We are all glad that Larry has more time now for his family and his garden. We'll miss seeing him at the helm, but we'll continue to benefit from his experience and his legacy.

Lingua Botanica wants to thank everybody that spilled the goods on Larry, especially Steve Olson, Rod Sallee, and Jan Schultz.

A Case for Moonlight Forays -- Moonworts in North America

Edna Rey-Vizgirdas, Forest Botanist, Boise National Forest

One of the challenges of being a botanist is sharpening your observational skills. We must slay the dragon of distraction and overcome the "green blur", that sense of walking through a plant community without really noticing what's there. Focus, discipline, being present in the moment. Zen and the art of botany. We zoom out to take in the big picture (the overstory, the dominant species) while not ignoring the little things – the cryptogams and belly plants, fine-filter stuff.

Cryptic plants are often the most captivating, perhaps because we have to work harder to find them. One particularly challenging group, grapeferns or moonworts, members of the genus *Botrychium*, in the Adder's-tongue family (Ophioglossaceae), are unique ferns that are commonly no larger than your thumb. The name *Botrychium* comes from the Latin "botry" – a bunch of grapes – referring to the grape-like clusters of small round spore cases (sporangia) on the fertile fronds. Moonworts collected by moonlight were once thought to have magical powers. Common moonwort (*B. lunaria*) was used in the incantations of witches and necromancers to raise the dead, and was thought to unlock locks and unshoe horses that tread on it. The crescent shaped leaves of *B. lunaria* suggested to early Europeans that it was influenced by the moon (Luna). European peasants believed that the leaves always faced the moon. Although these early notions may seem fanciful to us today, we are still on a learning curve with respect to moonwort ecology, taxonomy, and distribution.

Moonwort Biology

Botrychium species can be tough to survey for or identify, due in part to their diminutive stature and life history. Additionally, the taxonomy of the genus has evolved rapidly in the last decade based on work by a handful of experts, including the late Dr. Warren H. (Herb) Wagner and Dr. Donald Farrar. The Flora of North America describes 30 moonwort species, although several more taxa have since been described owing to additional discoveries and ongoing genetic studies.

Moonworts are dependent on mycorrhizal fungi throughout their life cycle, making it difficult to grow or successfully transplant individuals. Little is known about the specificity or habitat requirements of the mycorrhizal fungi. The fungal association allows *Botrychium* species to remain dormant for long periods, perhaps several years. Although prolonged dormancy can be advantageous during periods of drought or adverse conditions, it can seriously complicate survey and monitoring efforts.

After *Botrychium* spores germinate, they develop into subterranean, non-photosynthetic gametophytes (gamete producing plants). Fertilized zygotes develop roots, stem, and the aboveground fern-like structure, the sporophyte. The growth rate is so slow that ordinarily just a single leaf is produced per year.

Habitat and Distribution

In North America, moonworts are found in every state, Canada and Mexico. The greatest diversity in *Botrychium* is at high latitudes and high elevations, mostly in meadows and forest habitats (Wagner and Wagner FNA vol. 2). Distribution is often patchy, and disjunct populations and endemics are common. Several species of global or local conservation concern are on Regional Forester's Sensitive or Forest "Watch" lists. *Botrychium lineare* (slender moonwort), a federal candidate species, has been collected at elevations ranging from sea level in Canada to over 10,000 feet in Colorado, yet only 200 plants are known to exist. An Oregon species, Crater Lake grapefern (*B. pumicola*), occurs on a handful of sparsely vegetated, high-elevation pumice sites. Frenchman's Bluff grapefern (*B. gallicomontanum*) is endemic to only two sites in Minnesota. *Botrychium mormo* (little goblin fern), is a mere 3-1/2 inches tall, and sometimes does not appear above the leaf litter of the forest floor. During drought years, it may not appear at all. Some individuals lurking under the leaf litter are albinos, completely reliant upon the mycorrhizae for carbohydrates.

Botrychium species can be found in a variety of habitats, including old-growth cedar, sugar maple forest, mixed conifer forest, meadows, roadsides, and sand dunes. It's not unusual for several moonwort species to occur together in groups or "genus communities" which can be include some of the more rare and cryptic taxa. Of course, finding one of the larger species (like *B. multifidum,* leather grapefern, or *B. virginianum*, rattlesnake fern) can help expedite the survey process since they're easier to see. Crouching and/or crawling are the preferred moonwort survey methods, which makes thorough surveys of potential habitat very time and labor-intensive.

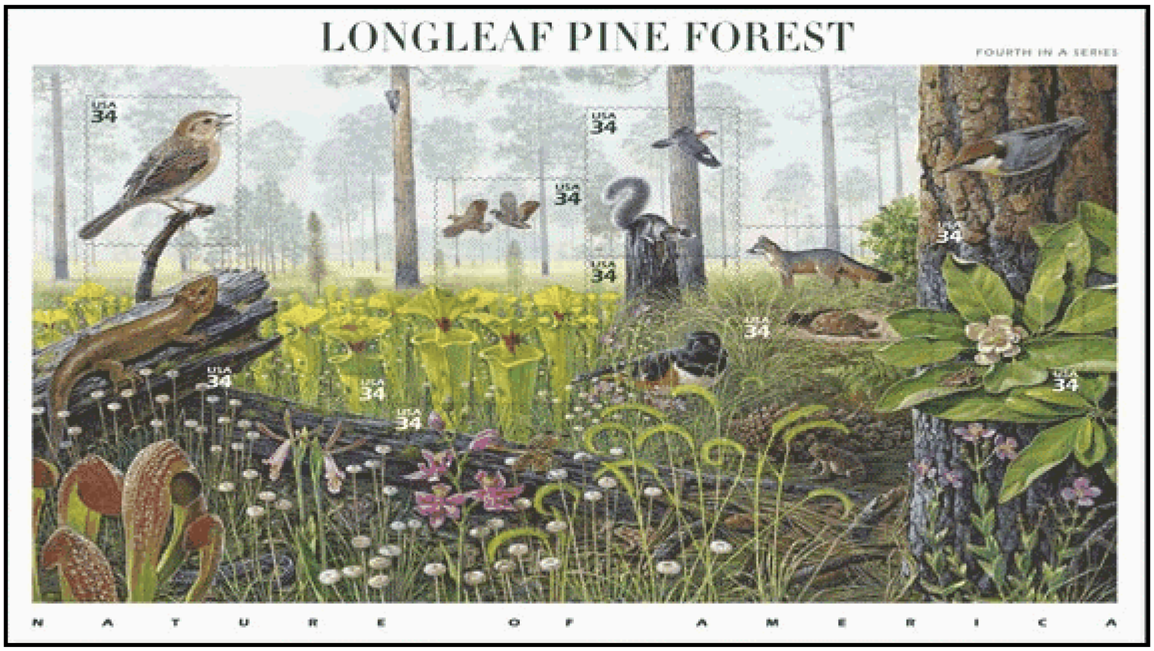
A few "hot-spots" for *Botrychium* diversity include eastern Oregon's Wallowa-Whitman National Forest, Glacier National Park, the Idaho Panhandle National Forest, the Superior National Forest, and Wisconsin's Chequamegon-Nicolet National Forest. Each of these locales harbors a dozen or so species of moonworts. Why are some areas rich in *Botrychium* diversity while other sites have few or no moonworts? The answer may lie with the distribution of mycorrhizal fungi, spore dispersal patterns, climatic conditions, or a combination of these or other factors. Moonwort biogeography is ripe for further research.

Perhaps you too will exhibit symptoms of "moonwort madness" – crawling on your hands and knees through forests and meadows in search of these elusive ferns; or dancing by the light of the moon when you find one! The search for *Botrychium* species and a desire to learn more about their ecological relationships is likely to challenge botanists and fern enthusiasts for years to come. And remember, you *can* conquer the dragon!

Check out the PLANTS database, NatureServe Explorer, and the Flora of North America websites for additional information on moonworts, including photographs and line drawings.

US Post Office to Release Longleaf Pine Forest Stamp in April 2002

The Longleaf Pine Forest pane of 10 stamps is the fourth in the Nature of America series, which is an educational series promoting the appreciation of North America's major plant and animal communities. To illustrate the diversity of species found in the longleaf pine forest, artist John D. Dawson portrayed 31 animal and plant species. Although the scene is imaginary, all species represented are appropriate and were recommended by scientists. A numbered key to the artwork appears on the back of the pane, along with a corresponding list of common and scientific names for 27 selected species.



Forest-Scale Native Plant Nurseries

The last edition of *Lingua Botanica* presented a summary of the National Forest Service Nursery Review. Although some members of the traditional FS Nursery community see the importance of the native plant materials propagation, the Nursery Review demonstrated that there was “room for improvement.” Were there’s a will, there’s a way. Some innovative National Forests (usually their botanists) have stepped in to fill the local-source native plant vacuum. Sometimes the need is for restoration material (like at Midewin National Tallgrass Prairie), other times the need is to reestablish rare species (as on the Francis Marion – Sumter National Forest). In every case, specialty nurseries have thrived to the extent that they’ve been able to engage partners. In some cases, these partners have been other federal or state agencies; in other cases the partners have been communities and businesses.

I firmly believe there is a place for the Forest Service nursery program in the burgeoning native and local-source paradigm. Until they are ready to more fully embrace those needs, energetic and dedicated men and women in the field will continue to define the new business of restoration and conservation planting.

Lingua Botanica presents, for your inspiration, accounts of three highly successful, home-grown native plant nurseries from around the country. The Hiawatha National Forest, San Bernardino National Forest, and the National Forests in North Carolina have very different programs that are used for very different purposes. In their differences, they share a spirit of daring, of dedication, and of purpose.

Sowing the Seed: Initiating a Native Plant Restoration Program.

Jan Schultz, Hiawatha National Forest; Ecological Restoration 1999. v17(4):239.

For several years, we have aspired to use native seed and plants of local origin in various restoration projects at the Hiawatha National Forest, which is located near the city of Marquette in the eastern portion of Michigan's Upper Peninsula (UP). We are concerned about maintaining the biodiversity and integrity of the local plant gene pool, controlling invasive plants, and ensuring the success of our short- and long-term restoration projects. The recent Executive Order 13112, (issued February 3, 1999) directs federal agencies to "provide for restoration of native species and habitat conditions in ecosystems that have been invaded." However, finding commercially available sources of native material form local sources has been a challenge for us.

Several partners, most notably the Wisconsin Electric Power Company, have recently helped us start our own native plant propagation program by funding two projects – a greenhouse renovation and a native plant restoration site – at Hiawatha's Marquette Interagency Conservation Center. The greenhouse and restored landscape produce a small quantity of the plants needed for our restoration work and also serve as places where we can hone our cultivation, propagation, and restoration techniques. Volunteers from Northern Michigan University and the Marquette community have assisted us in our efforts.

We renovated the greenhouse using an inflated double-hoop design and equipped it with natural gas and a mister system. Staff and local volunteers collect seed for greehouse cultivation from sites in the eastern UP, primarily within the Hiawatha National Forest, that we know to be indigenous. We harvest no more than 50% of the seed at a site an carefully record the harvest location and date. We chose first to grow those species that required little seed preparation, mostly cold stratification, and that had wide ecological amplitude. Taking this approach, we could outplant these species successfully in landscapes ranging from dry to mesic to wet-mesic.

The native plant restoration site measures about one-quarter-acre, and serves as an educational tool and a seed source for various projects. We organized the native plantings by the amount of overstory shading available at the site and the amount required by the individual species. We salvaged shade-loving deciduous forest herbs and ferns from several projects at Hiawatha where they could have otherwise been destroyed. We removed the sod using a sod-cutter, rototilled about two-inches deep, and planted and seed the desired natives (we did not use any herbicides). We are now beginning the third summer "post sod" and the forest plantings are well established and thriving. We planted the sunny areas of the site with native savanna-meadow species. These areas still require some weeding, but this has become less of a chore with each growing season.

Our native seed and plants have been, and will be, used in several restoration projects at Hiawatha, including an area within a wild and scenic river corridor, a gravel pit, a power- and gas-pipeline stie, and on landscape damaged by all-terrain vehicles.

They are also being used for road-side seeding, site enhancement for monarch butterflies, educational gardens, as seed source material, and for landscaping a new district office.

The most important factor in site preparation for native plant outplanting has been the removal of weeds, without the use of herbicides. We have successfully controlled weeds using multiple shallow tillings (two inches) at three week intervals through the growing season. We are also currently trying a nurse crop of annual oats (*Avena sativa*). Mulching our deciduous forest garden with deciduous leaves in the autumn has decreased the amount of spring and summer weeding necessary and creates a natural appearance. For larger scale restoration projects, we use a weed-free straw. We typically place the small plants that we grow from seed on eight- to 12 –inch centers.

The longer we work with our various plant restoration projects, the more techniques we learn. Our advice after several years of tinkering? And finally, share your enthusiasm for native flora with like-minded people who may be willing to contribute their time, expertise, and/or financial assistance.

Big Bear Green Thumbs: Native Plant Restoration Volunteer Program

San Bernardino, Big Bear Ranger Station

For the past decade, the San Bernardino National Forest has been conducting ecological restoration projects on numerous areas on the Forest. The Big Bear Ranger Station Native Plant Nursery has two greenhouses, a lathe house, and seed storage shed. With these facilities the District has grown and out-planted thousands of native plants and enhanced hundreds of acres of habitat for wildlife, federally listed plants and animals, and other degraded lands.

The U.S. Forest Service is seeking volunteers who enjoy working outdoors and interested in working for our native plant restoration program. Activities will include site preparation, seed collection, and out-planting of potted materials. Workdays will last from 9:00 A.M. to around 3:00 P.M. the second to last Saturday per month. The volunteer group will meet in front of the Big Bear Ranger Station at the flagpole except for September 28 when we will meet in front of the Big Bear Discovery Center. From our meeting site we will caravan out to the work site on the Forest. **Dates include March 23, April 20 (Earthday is April 22!), May 18, June 22, July 20, August 24, September 21, September 28 (National Public Lands Day), and October 19.**

Anyone interested in volunteering for these dates, or any additional dates or times, please contact **Dennis Casper at (909) 866-3437 ext. 3287** or **Linda Stamer** at **(909) 866-3437 ext. 3301**.

Southern Appalachian Native Plant Seed Mix

Gary Kaufman, National Forest in North Carolina

Exotic plant species are considered a major threat to the integrity of native communities on federal lands. Nonnative invasive plants tend to be more competitive and hold a reproductive advantage over native species. The roadside edge, other disturbed areas, and forest edges provide suitable habitat for rapid establishment and incursion by a number of exotic plant species. By quickly establishing appropriate native species along disturbed areas, it is anticipated that undesirable exotic species will be competitively discouraged. A 3-year study to identify appropriate native plant mixes for use on federal lands along the Blue Ridge Parkway was initiated in 1998 with money provided by the National Biological Survey. Short-term objectives for this study was to identify potential native plant species for quick establishment, collect local ecotypes of these species and experimentally study them at different sites along the Blue Ridge Parkway and the National Forests in North Carolina. Twenty-one grasses, three sedges, one rush, and forty-five forbs were gathered in 1998. In order to maintain genetic diversity within those selected species, an effort was made to collect from dispersed populations of each species. Half of the collections were selected from at least three sites for each species. One-quarter had five to ten collection sites. Nine separate families are represented in the collected forbs.

The collected grasses and forbs were established within increase beds at separate locations in the Pisgah National Forest, the Great Smoky Mountains National Park and Warren Wilson College. The three locations, totaling about 1and 1/2 acres in size, vary in elevation from 2200 to 5500 feet. These increase beds provided germplasm for additional establishment trials. After three years of establishment the number of species in the initial increase beds has been reduced to the hardiest species, having survived three successive droughts. The following species have been effective in various trials.

Cool Season Grasses: *Elymus virginicus, Elymus hystrix, Danthonia compressa*
Warm Season Grasses: *Tridens flavus, Chasmanthium latifolium, Saccharum alopecuroideum, Schizachyrium scoparium, & Andropogon gerardii*
Forbs: Solidago nemoralis, Solidago roanensis, Solidago odora, Pityopsis graminifolia, Penstemon canescens, Rudbeckia triloba, Coreopsis pubescens, Parthenium integrifolium, Monarda didyma, Monarda clinopodia, Aster saggitifolius, Ionactis linariifolius, Thermopsis villosa, Aster undulatus, Lobelia puberula, Helianthus atrorubens, Scutellaria incana, Helianthus resinosus, Packera anonyma, Eupatorium rotundifolium, & Liatris spicata

The size of the increase beds for individual species varies dramatically with the greatest quantity in grass production.

Sedges 2002

International Conference on Uses, Diversity, and Systematics of Cyperaceae

A three-day conference on the uses, diversity, and systematics of the sedge family (Cyperaceae) is planned for 6--8 June 2002 at Delaware State University. The sedges are a large, ecologically and economically important family found in many habitats and climates throughout the world. This conference is hosted by the Claude E. Phillips Herbarium of DSU and sponsored by the Natural Resources Conservation Service of the United States Department of Agriculture. The first day is devoted to programs by researchers on an array of subjects including systematics, weed ecology, horticulture, conservation, wetland restoration, and ethnobotany. On the second day, field trips to local areas will enable conference participants to see a variety of sedges, mostly members of the large and taxonomically complex genus *Carex*. Identification workshops, again primarily for *Carex*, will be held on the third day.

To be placed on the mailing list for future notices and registration, please send your name, address, and telephone number via e-mail to Robert Naczi at rnaczi@dsc.edu.

Partnering With Plants

Dave Harrelson, Endangered Species Update, September 2001

Once, clouds of a unique wildflower, the decurrent false aster (*Boltonia decurrens*), lined the banks of the Illinois River, but the construction of a system of locks and dams has nearly eliminated the plant's habitat. Loss of wetlands habitat also was a primary reason for the decline of the swamp pink (*Helonias bullata*), a plant endemic to freshwater wetlands along the eastern seaboard. In 1992, a single specimen of *Delissea undulata* was discovered in North Kona, Hawaii. Botanists were able to germinate seeds from this plant, which was thought to have been extinct since 1971, and today the speies appears to have a chance for recovery. Elsewhere in Hawaii, at least 12 native plant species are represented by only a single individual.

Faced with expanding development of natural areas, loss of pollinators, and over-collection for ornamental and other uses, many of our native plants face an uncertain future. Hawaii, California, Texas, Florida, and Puerto Rico have the greatest number of rare, imperiled, and federally listed plant species. Some plants, such as the endangered Tennessee coneflower (*Echinacea tennesseensis*), are known to contain substances that can be used to treat human illnesses. Two-thirds of the native plants of conservation concern are closely related to cultivated species.

As of March 31, 2001, 736 native plant species were listed as endangered or threatened under the Endangered Species Act. According to the Center for Plant Conservation (CPC), over 4,000 species of U.S. plants, roughly 25 percent of our country's entire known native plant species, are at some degree of risk. Of these, many hundreds could vanish in the next few decades.

Since its founding in 1984, the CPC has been working with the Fish and Wildlife Service to conserve and recover America's imperiled plant species. The CPC is one of very few national organizations in the U.S. dedicated solely to the conservation of our native plants. Based at the Missouri Botanical Garden, the CPC's network or 30 botanical gardens, arboreta, and related institutions collectively maintain the best curated and most secure collection of rare native plants and plant materials anywhere in the world. The CPC also maintains information on thousands of rare and endangered native plants. The status of these species in the wild, and especially those held in conservation collections, is constantly tracked. The CPC then provides this information to scientists, conservationists, land-management agencies, and many others.

The many rare and federally protected plants for which the CPC cares are maintained as security against extinction and as a pool of genetic material for use in restoration, research, recovery, and education. The CPC's participating institutions are currently reintroducing several endangered and threatened plant species to secure habitats in the wild. Just as important the CPC undertakes efforts to conserve rare plants in their natural habitats. With this in mind, the CPC has been recognized by the Fish and Wildlife Service for its technical and leadership qualities in the controlled propagation or rare native plants for recovery purposes. In July 2000, the CPC and the Service signed a memorandum of understanding at the World Botanical Congress in Asheville, North Carolina, establishing a framework for cooperation in plant conservation.

A cornerstone of the CPC's conservation programs is the National Collection of Endangered Plants. Currently at 575 species, it is one of the largest living collections of rare plants in the world. Genetically diverse, live plant material is collected from nature and carefully maintained within the CPC garden network in the form of seeds, cuttings, and mature plants. This material is propagated as needed and closely monitored until it can be restored to natural habitats.

Seed storage is another component of the CPC's conservation strategy for native plants. For example, as a member of CPC, the Berry Botanical Garden in Portland, Oregon, follows the standards and protocols for seed collection, storage, and maintenance developed by the CPC. The seeds of plants like the western lily (Lilium occidentale) are kept in a controlled environment at minus 18 degrees Celsius (0 degrees Fahrenheit). To reduce moisture in the seeds to the proper level, they are first dried with silica gel. They are then cleaned, packaged, and stored in freezers. Seeds preserved this way can remain viable for several decades, possibly centuries.

Research into the ecology and management of rare species, including many of those on the federal list of endangered species and threatened plants, is an integral part of the conservation activities of the CPC network. From seed storage to pollination biology and population genetics, scientists from member institutions engage in all aspects of conservation organization such as the Nature Conservancy, state Natural Heritage Programs, and the Fish and Wildlife Service.

Education is also a major part of CPC activities. Each year, millions of people visit participating gardens and arboreta where they can view and learn about native plant resources that most will probably never see in the wild. Interpretation and other education-oriented experiences are constantly being developed with the goals of increasing public awareness and promoting the stewardship of these natural treasures.

Both the CPC and the Fish and Wildlife Service anticipate increased mutual participation in the recovery process for endangered plant species. Likewise, we all hope that the new memorandum of understanding will lead to the establishment of new alliances (for example, local partnerships between CPC member institutions and national wildlife refuges) and other conservation efforts.

Over the next decade, there will surely be successes, and probably some failures, but the essential fact is that when we work together to develop coordinated conservation and recovery projects, both in cultivation and in the wild, the load is a little lighter, the work a little easier, and our common goals much more obtainable.

Colonization history and introduction dynamics of *Capsella bursa-pastoris* (Brassicaceae) in North America: isozymes and quantitative traits

B. Neuffer and H. Hurka, Molecular Ecology v8 (10) 1667-1681

Multilocus isozyme genotypic composition for aspartate aminotransferase (AAT), leucine aminopeptidase (LAP) and glutamate dehydrogenase (GDH) was studied for *Capsella* in the source continent, Europe (9000 plants from 593 populations), and in the colonized continent, North America (2700 plants from 88 populations). North America was depauperate in the number of genotypes (by 50%), but in terms of frequencies, a few genotypes were common and shared by both continents. Although some, very rare, genotypes were, however, unique for North America, our data provided no evidence to indicate that the introduced gene pools were reconstructed on a multilocus genetic basis after introduction. Instead, they argued for a considerable number of independent introduction events. Geographical distribution patterns of multilocus genotypes in Europe and North America were pronounced and enabled us to trace the colonization history of Californian *Capsella* back to Spanish ancestral populations and those of temperate North America back to temperate European gene pools. A random-block field experiment with 14 Californian populations from different climatic regions revealed that variation patterns of quantitative traits reflect ecotypic variation, and the ecological amplitude of *Capsella* in North America is similar to that in Europe, which can be traced back to the introduction of preadapted genotypes. It appears that certain multilocus isozyme genotypes are associated with certain ecotypes. The variable European gene pool of *Capsella* was essentially introduced into North America without major genetic changes.

Botanists discover a new species of conifer in Vietnam

Tim Stephens, UC Santa Cruz Currents Online, January 2002

An unusual conifer found in a remote area of northern Vietnam has been identified as a genus and species previously unknown to science. The limestone ridges where the tree grows are among the most botanically rich areas in Vietnam and certainly harbor many other undescribed species, but they are outside the country's protected reserves, said Daniel Harder, director of the UCSC Arboretum and a codiscoverer of the new species.

Harder spent several years in Vietnam as the founding director of a botanical conservation program for the Missouri Botanical Garden. During that time, he and his collaborators discovered more than 100 new species of plants. But the conifer now known as the golden Vietnamese cypress is by far the most remarkable of those discoveries, he said.

"For us to find a previously undescribed large tree like this indicates that there is probably a lot more to be discovered there," Harder said. "It's comparable to the recent discoveries of previously unknown large mammals in Southeast Asia, like the giant muntjac and the saola, a type of ox."

Other scientists involved in the conifer discovery included Vietnamese botanists Nguyen Tien Hiep and Phan Ke Loc, Russian botanist Leonid Averyanov, and Philip Cribb from the Royal Botanic Gardens, Kew, in the United Kingdom. They found the trees clinging to steep limestone ridges in a mountainous area known as Bat Dai Son near the Chinese border.

The scientists knew they had found something interesting and sent specimens of the plant to one of the world's leading conifer specialists, Aljos Farjon at Kew. Farjon was initially skeptical of the group's reported find, but when he received the specimens he was ecstatic, Harder said.

"He's spent 25 years studying conifers and had never had an opportunity to describe a new species before," Harder said.

Farjon classified the tree as a new genus within the cypress family (Cupressaceae), and he and the other botanists have named it *Xanthocyparis vietnamensis,* the golden Vietnamese cypress. Its closest relative is the yellow spruce of the U.S. Pacific Northwest, also known as the Nootka cypress. Previously classified as *Chamaecyparis nootkatensis,* the yellow spruce is now classified as the second species in the new genus *Xanthocyparis.*Harder noted that the name change from *Chamaecyparis nootkatensis* to *Xanthocyparis nootkatensis*is not likely to sit well with horticulturists and foresters because the abundant bibliographic information on this important timber tree is linked to the old name.

"They dislike it when botanists change the names of familiar species, but these two trees are clearly the closest relatives of each other," he said.

A formal description of the new species is expected to be published in the next issue of the botanical journal *Novon.* A description of the tree's natural habitat and associated species will appear soon in another botanical journal.

A distinctive and unusual feature of the new species is that it bears two different types of foliage on mature trees: needles and scale leaves. It produces fine, yellowish-brown, hard, fragrant timber that is highly prized by the local people. Logging has reduced the number of larger trees, but some very large and stately specimens still grow on the steep, rocky slopes of isolated mountain peaks, Harder said. The mountaintop ridges in Bat Dai Son hold remnants of a forest that was once much more widespread, he added.

"This tree was already rare and endangered when it was discovered, which lends urgency to putting in place some protections," Harder said. "These limestone mountains might actually harbor other valuable species, and it's all part of the national heritage of Vietnam."

Based on the work of Harder's botanical conservation program within Bat Dai Son, the provincial government of Ha Giang Province has established the Bat Dai Son protected area. Provincial protection is the first step toward national and international protection, Harder noted.

In addition to the cypress, the collaborative team of botanists exploring the area has found about two dozen new orchid species, a variety of interesting new shrubs, and numerous herbs and bulbs, including a half-dozen new species in the Jack-in-the-pulpit family (Araceae).

"We have sent specimens to specialists around the world, and that has really stimulated a lot of interest in the flora of Vietnam," Harder said.

Harder has made plant conservation a central programmatic theme for the UCSC Arboretum since taking the helm as director in October 2001. He noted that the Arboretum already has a significant collection of conifers from around the world, in addition to its renowned collections of plants from Australia, New Zealand, and South Africa. But conservation involves much more than growing rare plants in the gardens, Harder said.

"We want to be active partners in conservation efforts to protect not only the plants themselves but also the habitats in which they grow," he said. "I also see education as an important part of conservation, and we have a role in explaining for the public the significance of rare and threatened plants. The Arboretum has a lot of work to do in these areas."

Genetic variation in *Pueraria lobata* (Fabaceae), an introduced, clonal, invasive plant of the southeastern United States

Rebecca A. Pappert, J. L. Hamrick and Lisa A. Donovan
American Journal of Botany 2000 v87:1240-1245

Abstract
Pueraria lobata (kudzu), a clonal, leguminous vine, is invading the southeastern United States at a rate of 50 000 ha per year. Genetic variability and clonal diversity were measured in 20 southeastern U.S. populations using 14 allozyme loci. Within its U.S. range, 92.9% of the loci were polymorphic and overall genetic diversity was 0.290. Such high levels of genetic diversity are consistent with its history of multiple introductions over an extended period of time. The average proportions of polymorphic loci and genetic diversity within populations were 55.7% (range = 28.6–85.7%) and 0.213 (range = 0.114–0.317), respectively. The proportion of total genetic diversity found among populations was similar to species with equivalent life history characters (G_{ST} = 0.199). No regional patterns of variation were seen. The number of putative genotypes in each population ranged from 2 to 26. Mean genotypic diversity was 0.694, ranging from 0.223 to 0.955. Such high levels of genotypic diversity indicate that local sites are often colonized by several propagules (most likely seeds) and/or that sexual reproduction occurs within populations after establishment. An excess of heterozygosity was observed in populations with few unique genets, implying that selection for highly heterozygous individuals may occur in populations of *P. lobata.*

Introduction

Blanketed fields of kudzu, *Pueraria lobata* Ohwi, are a familiar sight throughout the southeastern United States. Since its introduction in the 1870s, kudzu has covered an estimated 3 million ha of land and currently spreads at a rate of 50 000 ha per year (K. Britton, personal communication). *Pueraria lobata,* a leguminous, twining vine with large trifoliate leaves, dominates by climbing over and shading everything in its path, killing native herbaceous and woody species. It roots easily from nodes and has a large tuberous root system, producing extensive clonal spread. Little biomass is allocated for structural support, allowing *P. lobata* to invest its resources into vine expansion and increased photosynthetic area (Sasek and Strain, 1988). *Pueraria lobata* was repeatedly introduced into the southeastern United States throughout the late 19th century and the first half of the 20th century. Introductions, first as an ornamental and subsequently as fodder and a means of erosion control, were widespread and usually undocumented. Although some research has been conducted on physiological aspects and methods of eradication of *P. lobata* (Wechsler, 1977; Miller, 1985, 1988; Sasek and Strain, 1988; Sharkey and Loreto, 1993), studies of the genetic composition of kudzu populations in the southeastern United States do not exist.

The genetic composition of an introduced, invasive species, such as *P. lobata,* is influenced by its history of introduction as well as its life history characteristics. Naturalized populations of species that have been intentionally introduced multiple times over an extended period should have more genetic diversity than species that were unintentionally introduced once or only a few times; each new introduction should increase the probability of introducing additional genetic variability. Ornamental species such as *Lathryus latifolia* (Godt and Hamrick, 1991), *Lonicera japonica* (Schierenbeck, Hamrick, and Mack, 1995), and *Albizia julibrissin* (Hamrick, unpublished data), which were intentionally introduced into the southeastern United States multiple times, generally have high levels of genetic variation in their naturalized range. In contrast, unintentionally introduced species such as *Bromus tectorum* (Novak and Mack, 1993), *Xanthium strumarium* (Moran and Marshall, 1978), and *Abutilon theophrasti* (Warwick and Black, 1986) often have little genetic variation in their naturalized populations. Based on its history of multiple introductions, populations of *P. lobata* in the United States should have relatively high genetic variation.

The intentional introduction of a plant species may also affect regional patterns of genetic variation if genetically differentiated propagules were introduced into different geographic regions. Such introductions could have been due to attempts to match native habitats to recipient sites (i.e., founder selection) or to the haphazard introduction of genetically differentiated propagules into these sites (i.e., founder effects). In either case, such foci of introductions may impact the distribution of genetic variation among present-day populations. Alternatively, with multiple nonselective introductions in each region followed by substantial gene exchange among populations, no such regional patterns should currently exist. Since *P. lobata* was repeatedly introduced throughout the southeastern states over many decades (1870s–1940s), we would not expect there to be genetically identifiable foci of introduction.

The genetic composition (number and frequency of genotypes) of relatively recently established local populations of an invasive, colonizing species such as *P. lobata* is of interest since it may provide insights into the mode of local population establishment. Given the extended time since the last intentional introduction (1940s), and the phenomenal spread of *P. lobata* populations since that time, the vast majority of extant populations are likely naturally established. Current populations may generally consist of one or only a few genotypes, with high levels of genetic heterogeneity among populations. This pattern would suggest that new populations are established by a few propagules (vegetative or sexual), which then grow primarily vegetatively. Alternatively, current populations may consist of many genotypes with relatively little heterogeneity among populations. This would suggest that after initial population establishment (by few or many propagules) additional genotypes are derived by sexual reproduction within the population or by secondary long-distance propagule recruitment from other populations. Based on viable seed production by *P. lobata* (Abramovitz, 1983; R. Pappert and J. Hamrick, personal communication), and successful seedling recruitment in a Maryland population (Abramovitz, 1983), we expect populations of *P. lobata* to contain many genotypes with relatively low levels of genetic differentiation among populations.

Genetic analyses of intentionally introduced species provide evidence for the maintenance of many unique genotypes within populations and low among-population heterogeneity. *Lathryus latifolia* (Godt and Hamrick, 1991) and *Lonicera japonica* (Schierenbeck, Hamrick, and Mack, 1995), both clonally spreading, introduced, invasive species, maintain high levels of genotypic diversity within their populations and relatively low genetic differentiation among populations. Furthermore, reviews of the plant allozyme literature for highly clonal species (Ellstrand and Roose, 1987; Hamrick and Godt, 1989) indicate that such species often maintain significant levels of gene and genotypic variation within their populations.

This paper represents an allozyme analysis of 20 southeastern U.S. populations of *P. lobata.* We address the following questions: (1) Does *P. lobata,* as expected from its history of multiple introductions, maintain high levels of genetic diversity?, (2) Can distinct foci of introduction be identified based on differences in the genetic composition of populations within different geographic regions?, and (3) Do local populations of kudzu consist of one or a few genetically distinct clones or do its populations often consist of many unique genotypes?

Materials and Methods
Sample collection and electrophoresis

Samples were collected from twenty populations of *P. lobata* throughout its southeastern U.S. range (Fig 1). Populations were separated geographically by at least 100 km. Most populations ranged between 1 and 2 ha, although ATH was much larger (~30 ha). At each site, 48 samples of fresh leaf material were collected, and the general location of each sample within the population was noted. To increase the likelihood of picking leaves from different clones, samples were chosen at least 6 m apart. Samples were taken from edges, as well as the interior of populations when accessible. Leaves were kept on ice for a maximum of 48 h until further processing. Leaves were ground to a wet paste with a mortar and pestle using a small amount of sea sand and phosphate extraction buffer (Mitton et al., 1979), which solubilized and stabilized the enzymes. The extract was then absorbed onto Whatman filter paper wicks, placed in microtiter plates, and stored at -70°C until used.

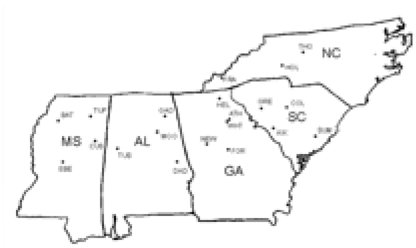


Fig. 1. Locations of *Pueraria lobata* populations. Locations include populations from NC (Franklin: FRA, Mt. Holly: HOL and Thomasville: THO), SC (Aiken: AIK, Columbia: COL, Greenwood: GRE and Summerville: SUM), GA (Athens: ATH, Athens: WHT, Forsythe: FOR, Helen: HEL and Newnan: NEW), AL (Dadeville: DAD, Gadsden: GAD, Moody: MOO and Tuscaloosa: TUS), and MS (Batesville: BAT, Columbus: CUS, Ebenezer: EBE and Tupelo: TUP)

Starch gel electrophoretic techniques were used to assess genetic diversity. Extracted proteins were run on 9% starch gels. We resolved 14 loci, using 11 enzyme systems. The following enzymes were assayed: menadione reductase (MNR, one locus), triose-phosphate isomerase (TPI, three loci), F-1,6-diphosphate (F16, one locus), shikimic dehydrogenase (SKDH, one locus), malic enzyme (ME, one locus), aconitase (ACO, one locus), fluorescent esterase (FE, one locus), diaphorase (DIA, two loci), mannose-6-phosphate (MPI, one locus), peroxidase (PER, one locus), and isocitrate dehydrogenase (IDH, one locus). Buffer systems included Poulik (MNR, TPI, ME, DIA, and PER) from Mitton et al. (1979) and 8 (FE), 4 (IDH, ACO), and 11 (F16, MPI and SKDH) from Soltis et al. (1983). Enzyme staining procedures followed Soltis et al. (1983) and Cheliak and Pitel (1984). The genetic basis of allozyme banding patterns was inferred from electromorph patterns with reference to typical subunit structure (Weeden and Wendel, 1989).

Genetic diversity analyses

Standard parameters of genetic diversity were used to describe genetic diversity at both the species and population levels (Berg and Hamrick, 1997). These parameters included percentage of polymorphic loci (P) and mean number of alleles per locus (A) and per polymorphic locus (AP). Effective number of alleles per locus (A_e) was also calculated using Hedrick's method (1983) for the "ramet" and "genet" data sets described below.

The "ramet" data set included genotypic data from all samples collected (N = 960). The "genet" data set gave a minimum estimate of the putative number of clones per population (range = 2–26). Samples with identical multilocus genotypes were considered to be the same clone and were only counted once per population (N = 202). Expected heterozygosity (H_e), observed heterozygosity (H_o), Wright's fixation index (F), as well as the chi-square test (Li and Horowitz, 1953) for deviations from Hardy-Weinberg expectations were calculated for the "ramet" and "genet" data sets. Values for H_e were averaged over all loci to obtain a mean value for each population. Each parameter was calculated at the species (subscripted by s) and at the individual population level (subscripted by p). As suggested in McClintock and Waterway (1993), calculations of genetic diversity parameters for the "ramet" and the "genet" data sets indicate how data from clonal organisms affect this standard genetic analysis.

Total genetic diversity can be separated into within- and among-population components. Heterogeneity in allele frequencies among populations was tested with χ^2 (Workman and Niswander, 1970). Partitioning genetic diversity within and among populations was determined using Nei's genetic diversity statistics (1973, 1977), with the "genet" data set only. Total genetic diversity, H_T, was partitioned into within-population genetic diversity, H_S, and among population genetic diversity, D_{ST}. The proportion of genetic variation explained by among population variation, G_{ST}, was calculated as: $G_{ST} = D_{ST}/H_T$. Two indirect estimates of gene flow (Nm) were obtained. The first estimates the number of migrants using Wright's (1931) F_{ST} (= G_{ST}; Nei, 1977). The second method, the "private" allele method, is based on the mean frequency of alleles found in a single population (Slatkin, 1985; Barton and Slatkin, 1986).

Nei's identity (I_n) and distance values (D_n) were calculated for each locus and population pair and averaged over all loci (Nei, 1972). An unweighted pair-group clustering phenogram (UPGMA) and a nonmetric multidimensional scaling plot (MDS) were produced using genetic distance values for the "genet" data set using NTSYS-pc to determine unique relationships among populations (Rohlf, 1992).

Clonal diversity analysis

To estimate comparative levels of clonal diversity among populations, two measures of genotypic diversity were calculated (Ellstrand and Roose, 1987). Simpson's diversity index (D) measures the genotypic diversity of clones within a population (Parker, 1979), $D = 1 - \Sigma[N_j (N_j - 1)/N_r (N_r - 1)]$, where N_j is the number of samples of the jth multilocus genotype and N_r is the number of samples collected for that population. Simpson's D varies between 0 in a population composed of a single clone and 1, in which every individual sampled has a unique multilocus genotype.

Fager's E (1972) measures the evenness of genotypic distribution within each population. This value varies from 0, in which all individuals have the same genotype, to 1, in which the population has completely uniform genotype frequencies. Fager's E is calculated as $E = (D - D_{min})/(D_{max} - D_{min})$. The parameters D_{min} and D_{max} are given as $D_{min} = (G - 1)(2N_r - G)/N_r(N_r - 1)$ and $D_{max} = N_r(G - 1)/G(N_r - 1)$, where G is the number of unique multilocus genotypes in each population and N_r is the total number of samples per population (Eckert and Barrett, 1993). Adjusting for D_{min} and D_{max} is necessary since the number of genotypes can be considerably lower than the number of samples per population (Parker, 1979).

Results

Genetic diversity

Pueraria lobata maintains high levels of allozyme diversity across the southeastern United States. Thirteen of the 14 loci surveyed (92.9%) were polymorphic in at least one of the 20 populations. ME was the only locus monomorphic across all populations. At the species level, there were 2.92 alleles per polymorphic locus (AP_s), the effective number of alleles (A_{es}) per locus was 1.49, and expected genetic diversity (H_{es}), was 0.294.

Within populations, allozyme diversity was considerably lower than at the species level. An average of 55.7% (range = 28.5–85.7%) of the loci surveyed were polymorphic. The mean number of alleles per polymorphic locus was 2.14 (range 2.0–2.6), the effective number of alleles was 1.38, and mean expected genetic diversity was 0.204 (range 0.108–0.298) for the ramet data set.

Only 16 of the 202 genotypes occurred in two or more populations. Ten genotypes were in two populations, five were in three populations, and one was in four populations. Although the observed number of multilocus genotypes per population may be somewhat underestimated, we are confident that genotypes were accurately distinguished, as identical genotypes were normally spatially adjacent. Expected heterozygosity values at the species and population levels for the "genet" data set were 0.290 and 0.213, respectively. The effective number of alleles was 1.51 and 1.39 at the species and population levels, respectively.

When using the "ramet" data set, 84 of 280 fixation indices (F) were significant ($P < 0.05$). The majority of the significant indices were negative, indicating an excess of heterozygotes. The large number of significant tests using the "ramet" data set is due, in part, to the repetition of genotypes within populations. In contrast, when using the "genet" data set, only 18 of 280 tests were significant. Fourteen of the locus-by-genotype fixation indices were significantly greater than zero, indicating an excess of homozygotes. Four were significantly less than zero, indicating an excess of heterozygotes. Five percent, or 14 of the 280 tests, should deviate from Hardy-Weinberg equilibrium, by chance. No patterns were detected across populations as significance values ranged over populations, as well as loci.

When the populations were arbitrarily divided into those with <10 clones vs. those with ≥10 clones, the mean observed heterozygosity of populations with few genotypes was higher (0.288 ± 0.098; mean ± 1 SD) than the mean for populations with many clones (0.235 ± 0.053). Perhaps more significantly, differences between mean observed and expected heterozygosity was related to the number of clones observed in the population. Populations with few genets have large excesses of H_o while populations with more multilocus genotypes approach Hardy-Weinberg expectations or have a slight deficiency of observed heterozygosity ($r = -0.746$, $N = 20$, $P = 0.0002$, for $H_o - H_e$ vs. G).

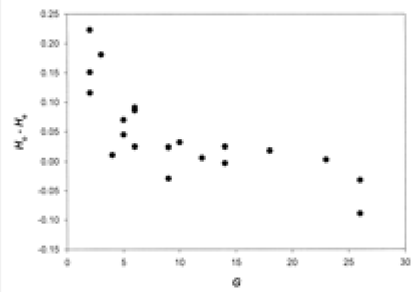


Fig. 2. Relationship between the difference of H_o (observed heterozygosity) and H_e (expected heterozygosity) vs. G (the number of unique genotypes found per population) for 20 populations of *Pueraria lobata.* Data are presented for the "genet" data set only, however the same relationship occurs for the "ramet" data set. See text for explanation

Chi-square analyses testing allele frequency heterogeneity among populations indicate significant differences ($P < 0.001$) for all 13 polymorphic loci for the "ramet" data set, whereas 12 of the 13 polymorphic loci (all but FE1) were significant (either $P < 0.005$ or $P < 0.001$) when using the "genet" data set. Allele frequencies for each population, at each locus, for both the "ramet" as well as the "genet" data can be obtained from the authors upon request.

Mean genetic diversity at the 13 polymorphic loci was relatively high (H_T = 0.313) when calculated with the "genet" data set. Eighty percent of the total diversity occurs within populations (G_{ST} = 0.199). Average genetic identity between populations was 0.895 (SD = 0.032). The highest identity was between MOO and EBE (0.988), and the lowest identity was between GAD and NEW (0.728) (data not shown).

UPGMA clustering, using Nei's genetic distance values for the "genet" data set, showed no novel relationships among *P. lobata* populations. In many cases, distance values were too low to define specific population clusters at the state or regional level. Similarly, the MDS plot did not show any regional patterning. Thirteen populations were clustered in the center of the two-dimensional MDS plot. Four of the outliers (FOR, HOL, NEW, and AIK) were loosely grouped together due to their low average paired-genetic distances; these four populations were basal on the UPGMA plot as well, due to the low genetic distance averages. BAT, TUS, and GAD were also outliers, however they were scattered at the periphery of the plot, in no distinguishable pattern. BAT, TUS, and GAD remained central in the UPGMA clustering, as their average genetic distances were between that of the 13 populations with low genetic distance averages, and the four populations with higher averages.

Gene flow (Nm) among populations using Wright's method was estimated to be 1.01. Slatkin's method, based on two private alleles with an average frequency of 0.031, was estimated to be 6.26.

Clonal diversity

Genotypic diversity, or Simpson's D, averaged 0.694 (SD = 0.226). GRE had the highest D value of 0.965, with a total of 26 putative genotypes, whereas MOO (with only two putative genotypes) had the lowest D value of 0.223. Fager's E averaged 0.753 (SD = 0.188), ranging from 0.263 (FOR) in which the genotypes were unevenly distributed, to 0.932 (GAD), where frequencies of five genotypes were evenly distributed within the population.

Discussion

Consistent with predictions based on its history of multiple introductions, *P. lobata* exhibits a high level of genetic diversity throughout the southeastern United States. Furthermore, the lack of any geographic patterns coupled with relatively little overlap of genotypes between populations is indicative of multiple introductions within local geographic regions followed by subsequent gene exchange and recombination. Viable seeds have been observed in many populations, indicating that gene exchange has occurred among genotypes that may have resulted from separate historical introductions. Such gene exchange could have occurred among adjacent populations with different introduction histories or within populations founded by propagules with varying multilocus genotypes.

Pueraria lobata is more genetically diverse than expected based on the mean values reported by Hamrick and Godt (1989) for species with similar life-history traits. Dicots, long-lived herbaceous perennials, species with regional ranges, and temperate species, on average, have <50% of their loci polymorphic at the species level, while *P. lobata* has 92.9% of its loci polymorphic. Even though levels of polymorphism decrease to 55.7% at the population level, the mean population values of Hamrick and Godt (1989) are again lower for species with this combination of life history characters when compared with *P. lobata.* The same holds for the other genetic diversity parameters.

The proportion of genetic diversity partitioned among *P. lobata* populations (G_{ST} = 0.199) is similar to that of outcrossing, animal-dispersed species (G_{ST} = 0.197), as well as species with both sexual and asexual reproduction (G_{ST} = 0.213; Hamrick and Godt, 1989). Although little is known about the breeding system and seed dispersal mechanisms of *P. lobata,* it reproduces sexually, as well as asexually (Abramovitz, 1983; Forseth and Teramura, 1986; R. Pappert, personal observation). Abramovitz (1983) found extremely low levels of seed set and seed viability, as well as short ($\leq$6 m) seed dispersal distances (for *P. lobata* populations located in Maryland). We have observed slightly higher seed germination rates than those reported by Abramovitz, ranging from 10 to 20% per population (Pappert, 1998). Of 245 naturally occurring seedlings observed by Abramovitz (1983) at the periphery of the Maryland populations, only one became established. The Maryland population studied by Abramovitz (1983) is near the edge of the geographic range of *P. lobata.* It is likely that seedling recruitment is higher in more southern populations. Nevertheless, the successful establishment of one or a few seedlings is enough to introduce novel genotypes into a population. Thus, under favorable conditions for seed production and recruitment, sexual reproduction could add significantly to the genotypic diversity of individual populations.

There are no discernible patterns with respect to the levels of genetic diversity, when comparing *P. lobata* with other invasive species with similar introduction histories and life history traits. *Lonicera japonica,* for example, has a significantly lower percentage of polymorphic loci (P = 75%), mean total heterozygosity at polymorphic loci (H_T = 0.288), and mean variation within populations (H_e = 0.258) than *P. lobata* (Schierenbeck, Hamrick, and Mack, 1995). At the population level, however, *L. japonica* has more polymorphic loci (P = 53.8%), but a lower expected heterozygosity (H_e = 0.189). Similarly, *P. lobata* has higher P, H_e, and H_T values than the invasive species *Casuarina cunninghamiana* (Moran, Bell, and Turnbull, 1989; Moore and Moran, 1989) and *Lathyrus latifolius* (Godt and Hamrick, 1991). However, *Robinia pseudoacacia,* a clonally reproducing, invasive, native tree, has more polymorphic loci, greater total levels of diversity, and higher mean genetic identity among populations than *P. lobata* (Surles, Hamrick, and Bongarten, 1989).

In contrast, *P. lobata* has more genetic diversity than several unintentionally introduced species. As was expected, little genetic variability is found in the naturalized ranges of *Bromus tectorum* (P = 3.46%, H_e = 0.009; Novak and Mack, 1993), *Abutilon theophrasti* (fixed banding patterns for most loci; Warwick and Black, 1986) and *Xanthium strumarium* (P = 15.4%; Moran and Marshall, 1978). Additionally, these are primarily selfing species, which further limits the possibility of genetic recombination and subsequent colonization with genetically variable genotypes. Obviously, genetic expectations for species that were intentionally introduced repeatedly as ornamentals or for other specific purposes should be distinguished from those for species that colonize new continents by happenstance. Within this context, interpretation of our results would have been improved if we had sampled from the native range of *P. lobata.* Logistic considerations precluded such collections, however.

Although *P. lobata* spreads vegetatively, very few multilocus genotypes are shared among populations, indicating that populations are not strictly founded vegetatively. Two scenarios could produce such high numbers of genotypes in some populations with so few genotypes in common among populations. First, some populations may have been established by several individuals from diverse sources, starting a population with high levels of genotypic diversity. Secondly, populations may start with relatively few founders, but subsequent pollen flow and seedling establishment introduces additional genotypic diversity into the population. Both scenarios would result in high genotypic diversity within populations. Seed dispersal, although it has not been described at a large geographic scale, is not unlikely. Many populations of *P. lobata* occur on roadsides and railroad embankments, areas where long-distance seed dispersal may be optimized. The high levels of genetic variation observed throughout the southeastern states does not indicate one or even a few points of introduction and subsequent spread from these points. Rather, our data support the conclusion that multiple introductions containing many diverse genotypes occurred in each geographical region.

Populations of *P. lobata* usually consist of more than one genetically distinct individual. Seed set is variable among populations, although many populations flower profusely throughout mid- to late summer. Some populations have copious amounts of seed, whereas others are barren. Of the populations that were revisited after seed set, those with more genotypes had much greater seed set, and subsequent germination (HEL, ATH, GRE), than those with fewer unique multilocus genotypes (MOO, WHT) (R. Pappert, personal observation). This observation suggests that populations with more genotypes are more likely to successfully outcross and set seed. Since environmental factors are also correlated with seed production in *P. lobata* (Abramovitz, 1983), populations growing under favorable conditions may flower more profusely, attract more pollinators, and produce more seed. The reproductive biology of *P. lobata* should be studied more intensively to determine whether widespread patterns of sexual reproduction are evident. Newly established populations also should be identified to determine the number of genotypes present during and subsequent to the founding event.

An interesting observation from our results is that populations with few genotypes (e.g., TUS, MOO, AIK, and NEW) have higher mean levels of observed heterozygosity and that observed heterozygosities are also higher than Hardy-Weinberg expectations. It is possible that selection has acted in favor of individuals heterozygous at a large proportion of their loci at some or several stages of the life cycle. Although the dominance of few genotypes per population has been suggested based on theoretical studies (Parker, 1979; Ellstrand and Roose, 1987), the mechanism of selection favoring heterozygotes was not proposed. In an experiment implemented subsequent to this study, individuals heterozygous for a high proportion of these allozyme loci accumulated more biomass and leaf area (Pappert, 1998).

In summary, *P. lobata* maintains high levels of genetic diversity throughout the southeastern United States. Factors that influence such high levels of diversity include multiple introductions over approximately five decades, successful sexual reproduction allowing gene flow within and among populations, as well as the founding of populations by more than one genetically distinct individual. *Pueraria lobata* provides a unique opportunity for further research into the actual dynamics and spread of clonal, invasive species. By studying the peripheral spread and mating system of *P. lobata* in greater detail, we could directly determine the general importance of sexual reproduction within populations and whether sexual reproduction is a major component in the spread of *P. lobata* into open habitats.

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Factoid: According to the USDA National Agricultural Statistics Service, the Horticulture Industry in the United States produces $10.6 billion annually (based on 1998 figures). This about as much as Americans spend on blood pressure medication each year, the world spends on perfumes, or North Americans spend on pet food.

2002 Hiawatha Boreal Flora Workshop

Jan Schultz, Hiawatha National Forest

The Hiawatha National forest will host one session of a Boreal Flora Workshop taught by Dr. Ed Voss on July 9 - 11, 2002 at the Clear Lake Educational Center near Munising, Michigan. It is recommended that students arrive at camp late afternoon on Monday, July 8th. Supper will be served at 6:00 on July 8th. Class will begin at 8:00 a.m. and end around 5:00 p.m. each of the following three days. The three-day course will be spent in the field within the Hiawatha National Forest as well as some lecture and herbarium study in the classroom.

The Clear Lake Education Center is located approximately 22 miles southeast of Munising. The facilities are rustic, but comfortable. Students will need to provide their own sleeping bag, pillow, and towel. Meals and snacks will be provided during the workshop.

The cost of the workshop is $300 per student. This fee will fund instruction and instructional materials, food, lodging, and transportation while at camp. The session is limited to 25 students. Due to the interest in the course expressed by several agencies, we will enroll the first two people per agency registering and paying (via job code or check) by April 1, 2002. After this time, we will offer the course to alternates on a first-come first-serve basis until the session is full. All registration after May 1, 2002 is final and non-refundable. Registration requires the following:

For questions on the workshop contact Jan Schultz at:
Marquette Interagency Conservation Center
1030 Wright Street
Marquette, MI 49855
Phone: 906-228-8491 - Fax: 906-228-4484
Email: jschultz@fs.fed.us

Bonus Links for the Hardcore

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Federal Botany Jobs

Check for these and other jobs of interest to botanists at http://usajobs.opm.gov/.
Remember, botanists make excellent rangers, planners, staff officers, and Forest Supervisors.
There are currently (20 March 2002) thirteen open Forest Service line officer positions. Some positions are only open to Federal employees. Those positions are indicated by an asterisk (*) in the last right hand column titled "Fed Only".

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POSITION	SALARY	GRADE/SERIES	APPLY BY	ANNOUNCEMENT NUMBER	LOCATION	FED ONLY
BOTANIST	$37,420 - 37,420	GS-0430-09/09	04/29/02	R5NP-02-209	Willows, CA	
BOTANIST	$37,420 - 37,420	GS-0430-09/09	04/29/02	R5NP-02-209	Eureka, CA	
BOTANIST	$37,420 - 37,420	GS-0430-09/09	04/29/02	R5NP-02-209	Redding, CA	
BOTANIST	$37,420 - 37,420	GS-0430-09/09	04/29/02	R5NP-02-209	Yreka, CA	
BOTANIST	$41,684 - 61,413	GS-0430-11/11	04/15/02	R2-062-02G	Boulder/ Durango, CO; Custer, SD	*
BOTANIST	$41,684 - 61,413	GS-0430-11/11	04/15/02	R2-063-02D	Custer, SD; Boulder/Durango, CO	*
BOTANIST (TRAINEE)	$24,701 - 39,779	GS-0430-05/07	Mar 29, 2002	MPP-ENTRY TRAINEES-2002	Troy, NC; Lufkin, TX	*
BOTANIST	$39,987	GS-0430-09	04/01/02	R512-989-02T	San Bernardino, CA	
BOTANIST; ECOLOGIST	$24,701 – 48,652	GS-0430-05/09	04/11/02	R801-012-02G	Heflin, AL	*
BOTANIST; ECOLOGIST	$24,701 – 48,652	GS-0430-05/09	03/28/02	AL-012-02D	Anniston, AL	
INTERDISCP. BOTANIST, ECOLOGIST, FORESTER	$22,737 - 34,451	GS-0430-05/09	04/04/02	PN-0210-02G	Portland, OR	*

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POSITION	SALARY	GRADE/SERIES	APPLY BY	ANNOUNCEMENT NUMBER	LOCATION	FED ONLY
BOTANIST	$30,597 - 58,867	GS-0430-07/11	04/12/02	OR-02-082MP/DE	Vale, OR	
BOTANIST	$30,597 - 37,428	GS-0430-07/09	03/28/02	CB-02-09-DE	North Bend, OR	

USDI FISH & WILDLIFE SERVICE POSTIONS

POSITION	SALARY	GRADE/SERIES	APPLY BY	ANNOUNCEMENT NUMBER	LOCATION	FED ONLY
BOTANIST	$22,737 - 28,164	GS-0430-05/07	04/03/02	TVA-02-052	Honolulu, HI	
BOTANIST	$30,597	GS-0430-07/11	04/08/02	FWS1-02-078	Stockton, CA	*

Banner Plant: *Gaillardia aristata*

Each month, a different plant graces the banner of *Lingua Botanica*.
Image courtesy of Eure Karin, Senne, Germany - Natural history courtesy of Steve Shelly.

The banner plant for this issue, *Gaillardia aristata*, is also the species being distributed in this year's "Celebrating Wildflowers" seed packets. Commonly known as blanketflower, or indian blanket, the genus is named for a French botanist, Gaillard de Marentoneau. The specific epithet refers to the bristles on the receptacle. Blanketflower is a cool season, short-lived perennial that occurs from southwestern Canada south to Oregon, Utah, Colorado, and South Dakota; it is introduced in California, the southwest, and several mid-western and New England states. In the wild, the species prefers prairies, dry meadows, and other open places, and seldom ascends very high in the mountains. It is often a pioneer following disturbance, and becomes a minor component in climax plant communities. The forage value is poor, but a moth (*Schinia masoni*) camouflages itself for protection on the heads of blanketflower -- the head and thorax of the moth blend with the ray flowers, while the crimson wings blend with the disc flowers (Ferner, J.W. 1981. A cryptic moth, *Schinia masoni*, on *Gaillardia aristata* in Colorado. Southwest Natur. 26:88-90). The plants are good competitors under moisture stress, making the species a popular choice for xeriscaping, but it does not compete well under light stress.

Afterword:
Celebrating the Future of America's Wildflowers!!!

Jenna Nerys Owen among the *Lupinus texensis*

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