ABSTRACTS – Oral Presentations

Keynote Speech

Genetic Considerations for Native Plant Materials Development

Kayri Havens*, Jeremie Fant, and Andrea Kramer
Chicago Botanic Garden, Glencoe, IL, khavens@chicagobotanic.org

The goal of plant restoration is the establishment of self-sustaining populations that are as capable of surviving stochastic and evolutionary challenges as healthy, natural populations. There are a number of important demographic factors to consider in restoration efforts, but most would agree that the provenance and genetic variability of source material play an important role in restoration success. In this talk we will discuss both quantitative and molecular genetic experimental approaches to determining appropriate seed transfer zones. We have applied both approaches to assess local adaptation and patterns of genetic variation in *Eriogonum* (buckwheat) and *Penstemon* (beardtongue) species in the intermountain west. In *Penstemon* spp. we have found interpopulational differences in floral morphology (presumably related to pollinator suites) and several other quantitative traits. In both taxa, we have found differences in seed germination characteristics related to population altitude and length of winter.

Genetics

Seed Zones for Maintaining Adapted Plant Populations

J. Bradley St.Clair[1]*, G. Randy Johnson[2], Vicky J. Erickson[3], Richard C. Johnson[4], and Nancy L. Shaw[5]
[1]USDA Forest Service, Pacific Northwest Research Station, Corvallis, OR, bstclair@fs.fed.us; [2]USDA Forest Service, Washington, DC; [3]USDA Forest Service, Region 6, Portland, OR; [4]USDA ARS, Western Regional Plant Introduction Station, Pullman, WA; [5]USDA Forest Service, Rocky Mountain Research Station, Boise, ID

Seed zones delineate areas within which plant materials can be transferred with little risk that they will be poorly adapted to their new location. They ensure successful restoration and revegetation, and help maintain the integrity of natural genetic structure. The value of seed zones is recognized in numerous policy statements from federal and state agencies. Results from common garden studies indicate that local sources are often best adapted to local environments, although the degree of local adaptation differs between species and between traits within species. Seed zones have been used for over 60 years in forest trees, whereas seed zones for grasses, forbs and shrubs used in restoration are largely lacking. We discuss several studies that have been completed or initiated to study adaptive genetic variation and the development of seed zones in species widely used in restoration in the western United States.

Genetic Diversity Considerations for Native Wildflower Seed Production: The Case of *Coreopsis leavenworthii*

David M. Czarnecki II[1]*, Zhanao Deng[1], Jeffrey G. Norcini[2], Fred G. Gmitter[3], and Madguhuri N. Rao[3]
[1]University of Florida/IFAS, Gulf Coast Research and Education Center, Wimauma, FL, aggator@ufl.edu; [2]North Florida Research & Education Center, Quincy, FL; [3]Citrus Research and Education Center, Lake Alfred, FL

Genetic diversity is an important issue to end users of locally or regionally-adapted ecotypes of native wildflower seeds. However, seed production methods in general might inadvertently decrease the level of genetic diversity found in the source populations. The case of *Coreopsis leavenworthii* (Leavenworth's coreopsis) is an example of how production practices can still be profitable while maintaining an indiscernible level of genetic diversity between natural and production populations. *Coreopsis leavenworthii,* an obligate outcrossing species that is nearly endemic to Florida was screened for phenotypic and genetic variation in a common garden study and with Amplified Fragment Length Polymorphism molecular markers. Molecular analyses indicated that the diversity from production populations G1, G2, and G4 together held 79.9% of the diversity of all the natural populations sampled. Furthermore from G1 to G4 the diversity changed by only 3.6%. The common garden study grouped populations of plants into three clusters and was supportive of genetic data. Production populations were found to cluster with the most closely related geographic regions of their lineage. When molecular data were compared to phenotypic data a similar result was found.

Molecular Ecology Study of Purple Prairie Clover in Illinois

Danny J. Gustafson
The Citadel, Charleston, SC, danny.gustafson@citadel.edu

Two different molecular markers were used to characterize the genetic relationships of *Dalea purpurea* (purple prairie clover) from remnant and restored Illinois tallgrass prairies and Konza Prairie, Kansas. The remnant Illinois populations where less genetically diverse than the restored Illinois populations and the Kansas population. These restored Illinois populations were established with at least two locally collected seed sources. There was little population divergence (F_{st} = 0.042), which is consistent with other perennial forbs, while the genetic relationships among populations reflected geographic proximity. In a greenhouse competition experiment, there were no differences in performance between seedlings from remnant and restored Illinois populations, but plants from Kansas were significantly smaller than Illinois plants. Genetic diversity and competitive ability was not associated with the size of the original source population. These data suggest that using multiple local seed sources for restoration projects will maintain the local gene pool while enhancing the regional genetic diversity of this species.

Genetic Considerations for Wildland Forb and Shrub Restoration Plantings
E. Durant McArthur
USDA Forest Service, Rocky Mountain Research Station, Shrub Sciences Laboratory, Provo, UT, dmcarthur@fs.fed.us

The objectives of this research are to evaluate the genetic variation of forb and shrub species important for use in restoration and rehabilitation of depleted shrub steppe, woodland, and mountain forb communities. Genetic variation is being assayed by examination of isozymes and DNA-based molecular genetic markers including RAPDs, AFLPs, and ISSRs for both indigenous and artificially seeded populations. By determining patterns of genetic variation, inferences can be drawn as to the natural distribution of populations and ecotypes on landscapes and how seeding might be appropriate or not. Studies on seeded populations can contribute to the understanding of how this activity has impacted indigenous populations. Natural population genetic patterns have been gathered for a suite of more than a dozen forb species from shrub steppe and woodland communities, 5–7 study populations per species (*Astragalus utahensis, Balsamorhiza sagitatta, Crepis accuminata, Erigeron pumilus, Eriogonum umbellatum, Lomatium dissectum, L. grayi, Lupinus argenteus, L. sericeus, Penstemon deustus, P. speciosus, P. longifloia,* and *Vicia americana*). In general, these forb species are insect pollinated and composed of relatively small, discrete populations; a consideration when restoration plantings are planned. For the current work on mountain forb species (*Castilleja miniata, Chamerion angustifolium,* and *Geranium richardsonii*), 15 study populations per species are being evaluated. In addition, genetic patterns have been explored for two widespread, wind-pollinated shrubs (*Artemisia tridentata* [big sagebrush] and *Atriplex canescens* [fourwing saltbush]). These shrubs have much larger breeding populations and display much evidence of hybridization but nevertheless display subspecific and ecotypic site adaptation. Case studies of indigenous and seeded populations of perennial blue flax (*Linum perenne* and *L. lewisii*) and of seeded *Penstemon palmerii* (Palmer penstemon) and indigenous sympatric penstemon species show no introgression or hybridization. Conversely seeded and indigenous *Sphaeralcea* (globemallows) are rife with introgression, an apparent natural condition in the genus.

Cultural Practices

The Logistics in Seed Production for South Texas Ecotypic Releases
John Lloyd-Reilley and Shelly D. Maher*
USDA NRCS, E. “Kika” de la Garza Plant Materials Center, Kingsville, TX, John.Reilley@tx.usda.gov

The concept of the ecotype release is to mix numerous collections of a species in an effort to provide a broad spectrum of the genetic makeup adapted to a specific ecoregion. How many collections are necessary to provide a good representative sample of that species in a particular ecoregion? How much genetic diversity is inherent within and between collections of a species in that ecoregion? And if we mix multiple collections of a cross breeding species, do we know the ploidy levels of these collections, and have we taken precautions not to produce sterile hybrids? The ecotype release by nature is a wild creature, unlike its tame, homogenized relative the cultivar. Ecotype collections may have multiple growth forms and differing dates of seed maturity, which will complicate harvesting if mixed together in the same field. Furthermore, how many isolated fields are necessary to reflect the spectrum of a species' genetics? How many isolated fields are feasible? Other classic production issues that must be addressed with an ecotype release include seed drying, seed storage, seed structure, and how common cultural practices may effect production.

Influences on Wildflower Seed Yields by Row Spacing and Mulching Practices, and Improving Seed Production in Wild Populations for Seed Harvesting

Robert L. Johnson* and Val Jo Anderson
Department of Plant and Wildlife Sciences, Brigham Young University, Provo, UT, robert_johnson@byu.edu

The effect of between row spacing of 0.61, 0.91, and 1.22 m on seed yield was conducted on *Erigeron pumilus* (vernal daisy), *Erigeron speciosus* (pretty daisy), and *Chrysopsis villosa* (hairy goldenaster) in 2005 and 2006. Effects of within row spacing of 15.2, 30.4, and 46.7 cm in combination with paper, plastic, and weed fabric mulches were tested on *Sphaeralea munroana* (Munroe's globemallow), *S. coccinea* (scarlet globemallow), and *S. grossulariifolia* (gooseberry-leaf globemallow). We conducted another study to determine if seed production in wild populations can be enhanced by combinations of fertilizer, pruning, and competition reduction. Available moisture was determined to be the limiting factor, which factor increased potential seed yield by competition removal. We also documented seed predation rates primarily by capitivorous fruit flies (Tephritidae) on *Balsamorhiza sagitatta* (arrowleaf balsamroot), *Wyethia amplexicaule* (mulesears), *Crepis acuminata* (mountain hawksbeard), and *Agoseris glauca* (mountain dandelion). Seed yield losses vary by species and year but can be economically significant, in some cases near 90% seed loss. Controlling seed predators can greatly enhance seed yield. Maximization of seed yield in both agricultural systems and wildlands requires consideration of multiple factors.

Subsurface Drip Irrigation for Seed Production of Intermountain Wildflowers

Clinton C. Shock* and Erik B.G. Feibert
Oregon State University Malheur Experiment Station, Ontario, OR, clinton.shock@oregonstate.edu

In the Intermountain West native wildflower seeds from commercial production are necessary to provide the quantity of seeds needed for restoration efforts. Inconsistent seed productivity over years is a major limitation to economically viable seed production from unirrigated sites. Variations in spring rainfall and soil moisture result in highly unpredictable water stress during floral initiation, flowering, seed set, and seed development. Conventional sprinkler or surface furrow Irrigation could promote seed production, but risks encouraging weeds. Seven wildflower species were established by direct seeding using a tractor and planter: *Eriogonum umbellatum, Lomatium triternatum, L. grayi, L. dissectum, Penstemon acuminatus, P. deustus, and P. speciosus.* Prior to planting, drip tape was buried at 0.3 m depth between pairs of plant

rows. By burying drip tapes at 0.3 m depth, and avoiding wetting of the soil surface, we hoped to assure flowering and seed set without encouraging weeds or opportunistic diseases. Irrigation water was applied by subsurface drip irrigation over 4–5 weeks with timing to help assure flowering and seed set totaling 0, 100, and 200 mm. Subsurface drip irrigation effectively supplied water without wetting much of the soil surface or stimulating much weed seed emergence. Seed yield responses of *Penstemon acuminatus, P. deustus, P. speciosus* to irrigation were not significant in 2006, probably due to above average precipitation and precipitation timing. *Eriogonum umbellatum* flowereed last and responded to irrigation. The *Lomatium* species were insufficiently developed in 2006 to produce seed crops. Subsurface drip irrigation appears to be an option for native wildflower seed production.

Establishment and Seed Production of Native Forbs Used in Restoration

Jessica Wiese[1]*, Fabian Menalled[1], James Jacobs[2], and Susan Winslow[3]
[1]Montana State University, Bozeman, MT, jessica.wiese@myportal.montana.edu; [2]USDA NRCS, Bozeman, MT; [3]USDA NRCS, Bridger Plant Materials Center, Bridger, MT

There is great interest in incorporating native wildflowers into seed mixtures for conservation plantings and disturbed land revegetation projects. Despite this interest, and unlike the marketing of non-native species by the commercial floriculture industry, there is a lack of species-specific information in many aspects of native forb seed production including seeding techniques, seedling emergence, plant growth and development, seed production characteristics, and stand management. A critical component in the production of native wildflowers is securing successful establishment of these species as weed competition for water, sunlight, and nutrients threaten their successful establishment and growth. More specifically, there is a lack of herbicides labeled for weed control in wildflower seed production. To fill this knowledge gap, we examined the impact of pre-emergence and post-emergence herbicides on 5 wildflower species *Dalea candida* (prairie coneflower), *Gaillardia aristata* (blanket flower), *Penstemon eriantherus* (fuzzy tongue penstemon), *Phacelia hastata* (silverleaf phacelia), and *Ratibida columnifera* (slender white prairie clover) under greenhouse conditions. Preliminary results show that trifluralin and DCPA were the least injurious pre-emergence herbicides. Post emergence screening included linuron, clopyralid, fluazifop p-butyl, imazapic, halosulfuron, clethodim, and pendimethalin applied at four rates, labeled, 2/3X, 1/3X, and no herbicide. Clopyralid proved injurious to all wildflower species while all other herbicides tested showed no difference in biomass or density. Results of this study will be used at a large-scale field experiment assessing the impact of herbicide application on weed control and wildflower injury. These studies will provide growers and land managers valuable information that will improve their ability to commercially grow native wildflowers and clarify the impact of weeds on the competitive ability and growth of native wildflowers.

Identifying Management Strategies for Pests Affecting Native Forb Seed Production

Robert Hammon
Colorado State University Extension, Grand Junction CO, bob.hammon@mesacounty.us

Many species of native forbs are grown for seeds in western Colorado and eastern Utah. Seed production of several species of legumes, composites, and *Penstemon* species has been affected by insect pests and fungal pathogens. We have made field observations and collections and conducted control trials over the past 18 years to investigate their impact on seed production. Generalist pests such as *Lygus* (Hemiptera: Miridae) are widespread, and can have significant impact on several species of seed crops. Several species of specialist seed feeding weevils (Coleoptera: Curculionidae) and seed beetles (Coleoptera: Bruchidae) have impacted legume seed production. An undescribed species of stem feeding weevil (Coleoptera: Curculionidae) has killed entire fields of several *Penstemon* species in southwestern Colorado. Production of *Hedysarum boreale* seeds has been impacted by a seed feeding beetle (Coleoptera: Bruchidae: *Acanthoscelides* spp.), with one previously undescribed species collected from Cache County Utah. Head feeding flies (Diptera: Tephritidae) have impacted collections and production of several species of composite seeds. A previously undescribed species of caterpillar (Lepidoptera: Pyralidae: *Pima* sp) was discovered feeding within the pods of *Lupinus sericeus* in Delta County Colorado. We will discuss monitoring and management plans for these and other pests affecting native forb seed production.

Effect of Fertilization on Seed Production of Florida Ecotypes of Coreopsis

Jeffrey G. Norcini* and James H. Aldrich
University of Florida/IFAS, North Florida Research & Education Center, Quincy, FL, wldflowr@ufl.edu

One of the major impediments to seed production of regionally-adapted native wildflowers has been and continues to be the limited amount of scientific, nonproprietary information about cultural practices that will improve yields. Effects of fertilization and season of harvest on seed production were investigated in 2003 for a north Florida "ecotype" (composite from populations in four north Florida counties) of *Coreopsis lanceolata* (lanceleaf coreopsis) and in 2004 for a central Florida ecotype of *Coreopsis leavenworthii* (Leavenworth's coreopsis). Containerized plants were grown in a soilless substrate amended with Osmocote 18N-2.6P-10K (18-6-12; 8-9 month formulation) at one-half the low, low, and medium label rates for container-grown herbaceous plants (1.8, 3.6, and 5.4 kg/m^3, respectively). Seeds of *C. lanceolata* were harvested in June, and then again from July to October after plants had been cut back and reflowered while seeds of *C. leavenworthii* were harvested in late May to mid-July, and then again from late July to late October after plants had been cut back and reflowered. For both species, seed yield and quality were best for the early harvests, and seeds also ripened more uniformly at that time. Fertilizer enhanced seed production of both species mainly by increasing mature head production, with both species being more responsive to increased fertilization early in the season than later. June-harvested seeds of *C. lanceolata* were 67% viable but only 21% of the viable seeds germinated; July–October seeds only were 25% viable but 50% germinated. In contrast, germination of viable *C. leavenworthii* seeds was nearly 90% or more for both harvests, but there were more viable seeds for May–July than for July–October (75% vs. 57%). Based on results of both studies, coreopsis seed yields are quite responsive to fertilization, with the magnitude of that effect greatest in late spring/early summer after the first flush of flowers.

Pollination

Controlled Pollination in Wildflower Seed Production

Susan M. Stieve
Ornamental Plant Germplasm Center, The Ohio State University, Columbus, OH, stieve.1@osu.edu

The Ornamental Plant Germplasm Center (OPGC) currently maintains collections of more than 3,500 accessions consisting of about 260 herbaceous ornamental genera, most of which are cross-pollinated. OPGC facilities include ample field space and more than 743 m^2 of greenhouse space, making year-round controlled pollination and seed production possible. Greenhouse pollination is accomplished in 6 m x 9.1 m compartments. Plants are grown in pots and automated irrigation is utilized when possible. Field-pollinated plants are transplanted into black plastic or straw-covered mulched rows with T-tape drip irrigation. Field cage frames are 6.4 m long, 2.1 m wide, and 2.1 m tall; screens are placed over the framework and edges secured under soil, and pollinators are introduced at anthesis through a Velcro or zipper door. Due to the diversity of accessions, which include annuals, biennials, and perennials with varying plant and floral morphologies, the Center must meet diverse pollination requirements. Pollinators including *Apis mellifera* (honey bees), the family Calliphoridae (blue bottle flies), and *Bombus impatiens* (bumblebees) have been used successfully at the Center for pollination to regenerate seeds. Bumblebees, initially considered the most expensive pollinator, were found to be the most cost effective and best overall pollinator. They pollinate in small, confined spaces over a wide temperature range and are effective for all flower morphologies observed. Additionally, *B. impatiens* are easy to order, require minimal labor to maintain, and are cost effective due to hive longevity of 2–3 months and the ability to move hives easily from one pollination compartment to another. Cardboard hives in field cages are protected from rain by placing in a plastic bin, strapping to a stepstool, and facing hive entrance away from prevailing winds.

Selecting and evaluating bee pollinators for restoration seed production: the example of *Osmia* spp. (Hymenoptera: Megachilidae) and *Hedysarum boreale* Nutt. (Fabaceae)

Katharine A. Swoboda[1]* and James H. Cane[1,2]
[1]Biology Department, Utah State University, Logan, UT, katie@biology.usu.edu; [2]USDA ARS, Bee Biology and Systematics Laboratory, Logan, UT

Tons of seeds of *Hedysarum boreale* (Utah sweetvetch) are desired for extensive rehabilitation of degraded rangeland in the U.S. Rocky Mountains and Intermountain

West. Results of manual pollination field trials in 2003 suggest that *H. boreale* is self-compatible but requires bee visitation for seed set, and a manageable bee pollinator is needed to farm affordable seed. An assortment of bee species in the families Apidae and Megachilidae were found to visit *H. boreale* flowers at several sites in Utah and Wyoming in 2004 and 2005. In general, *Osmia* species were an important component of *H. boreale* pollinator faunas in both survey years and at most sites. In this study, two species of native cavity-nesting *Osmia* were selected and evaluated for their effectiveness as *H. boreale* pollinators. Both *Osmia bruneri* and *Osmia sanrafaelae* proved to be effective pollinators of *H. boreale* in terms of average number of pollen grains deposited per single flower visit, and were able to nest using *H. boreale* as their only source of forage material. These results suggest that *Osmia bruneri* and *Osmia sanrafaelae* could be developed for managed pollination of *H. boreale*.

Wild-Collected Seed

Wild Harvesting of Wetland and Upland Native Seed for Habitat Restoration

Calvin L. Ernst
Ernst Conservation Seeds/Ernst Southern Native Seeds, Meadville, PA, calvin@ernstseed.com

Native species growing in rare and extreme ecosystems do not lend themselves to cultivation and conventional harvest. The demand for seeds to restore vegetation on rare ecosystems is greater than our ability to grow these by cultural means. Our methods for wild harvest vary, from simply hand picking individual plants or species to mass collecting a combination of species with vacuum strippers. Our wild harvests have centered on native species that are in demand and do not lend themselves to cultivation in an agricultural sense, or where methods of cultivation have not been developed. We have studied and developed methods of protecting and enhancing wild stands for harvesting. We are using timely clipping, fire, and chemical means to control invasive competition in native donor sites. These methods of harvest require intense conditioning, cleaning, and storage of the harvested seeds. We have 20 years of experience with wild harvest. Our trial and error methods have resulted in many successes and some failures. Wild harvest can be an environmentally responsible means of producing seeds for restoration and protecting both the donor and recipient ecosystems.

Field Production vs. Wild Collection and Why We Do It, an Eastern Perspective

Mark B. Fiely
Ernst Conservation Seeds, Meadville, PA, hortpath@ernstseed.com

Production of many native herbaceous species began with hand or mechanical collection from natural stands. Over time, production limits of natural stands and a desire to produce species from remote areas have forced many seed companies to these species in monoculture production fields. Since 1999 we have produced a substantial percentage of our native species seeds in monoculture production fields. To facilitate development of these fields we experimented with germination protocols to produce our transplants. We observed the yields obtained with no inputs other than irrigation, cultivation, hoeing, and harvesting. We then began experimenting with cultural practices to improve yield. The experiences we have had with natural stand production and monoculture field production have led us to a number of conclusions. Most native species can be more profitably produced in monoculture than from natural stands. This is true whether harvesting by hand or machine. Provided weed control is adequate and cleaning equipment sufficiently versatile to remove inert matter and weeds, mechanized harvest from monoculture stands is the most cost effective method for producing most native species. There are exceptions for us, for example, *Carex vulpinoidea* (fox sedge), which is more cost profitable to harvest from natural stands.

Wildland Seed Collecting in Great Basin States

Scott L. Jensen
USDA Forest Service, Rocky Mountain Research Station, Shrub Sciences Laboratory, Provo, UT, sljensen@fs.fed.us

Much of the land base in western states is managed by federal and state agencies which regulate wildland seed harvest through the sale of seed collection permits. Private collectors obtain a permit to harvest seeds then sell collected material to private seed companies who in turn market those products. Much of this seed is purchased by and replanted on federal and state lands in restoration projects. Numerous native shrubs and forbs and some grasses lend themselves to wildland collection but many others either cannot be collected in adequate abundance or are too costly to harvest to justify wildland collection. Characteristics of both the floral community and the individual species determine whether the stand or species has potential for wildland harvest. Good plant density, tall upright plants, long seed retention periods, and large seed size are desirable attributes. Learning the locations of several productive stands and monitoring seed development are critical to successful harvest. Numerous events can render all or a portion of a typically fruitful stand nonproductive any given year. Access to multiple populations increases the chance of harvest. On public lands, restrictions are often placed on harvesting methods to protect resources. Generally these specify hand harvesting only, and in so doing restrict mechanical methods. Learning techniques to increase harvesting efficiency can be the difference for a species with marginal morphological or phenological characteristics to be wildland collected. Knowing approximate seed yields from bulk material permit decision making based on harvest rates. Appropriate handling through sale is vital to a quality product. With appropriate planning and some know how commercial quantities of many native species can be harvested from wildland stands. Species that don’t lend themselves to bulk collecting can be harvested in smaller quantities for increase in agronomic settings.

Collection, Conservation, and Seed Zones for Tapertip Onion (*Allium acuminatum* Hook.)

Richard C. Johnson*, Barbara C. Hellier, and Theodore J. Kisha
USDA ARS, Plant Germplasm Testing and Research, Washington State University, Pullman, WA, rcjohnson@wsu.edu

Native germplasm adapted to the Great Basin is needed for revegetation and restoration efforts. This requires comprehensive germplasm collection, field evaluation in common gardens and establishing links between genetic variation and environmental/geographic factors across the landscape. A collection of 55 populations of *Allium acuminatum* (tapertip onion) representing 20 level IV Omernik ecoregions was completed in 2005. Common gardens were established in 2006 at Pullman and Central Ferry, WA. Emergence in 2006 was highly variable but the data showed differences associated with collection location, suggesting genetic variation across the landscape and the potential for mapping seed zones. Traits with strong location effects ($P<0.001$) included bolting and flowering dates, leaves per plant, scape length, and flower color. Collection location latitude correlated with the number of bolted plants ($r= 0.52^{**}$, n=53), leaves/plant ($r= 0.31^{*}$, n=53), and maturity date ($r=0.32^{*}$, n=37). Collection longitude correlated with seed/plant ($r= 0.36^{*}$, n=36) and flower color ($r= -0.36^{*}$, n=43), and collection elevation with bolting date ($r= 0.36^{*}$, n=44). Sequence Related Amplified Polymorphisms (SRAP) analysis also showed genetic differences among germplasm collected from different locations. Matrix correlation between resemblance coefficients derived from SRAP markers and geographic factors based on latitude, longitude, and elevation was significant ($r= -0.17^{**}$, n=1326). These studies show *A. acuminatum* traits varied with collection location and that certain traits were associated with geographic factors. This suggests developing seed transfer zones, adapted germplasm, and *in situ* conservation sites for *A. acuminatum* should be possible.

Harvesting, Conditioning, Storage

Harvesting For Diversity in Native Wildflower Seed Increase Fields

Amy Bartow
USDA NRCS, Corvallis Plant Materials Center, Corvallis OR, amy.bartow@or.usda.gov

Every wild seed collection represents a sample of a population (a “selection”). There are ways of collecting wild seed that can create a sample of a population that is representative of the initial population. If that collection is being used to create a field for seed increase, techniques need to be adjusted so the harvest of the crop does not become another “selection”. Swathing and combining generally is a good choice for species that mature evenly within the individual plants as well as among the entire field. Instead of traditional swathing and combining, some species can be swathed using a “diapered” swather. This method also is a good choice if the seeds do not shatter readily at maturity. For species that shatter easily, are less uniform in maturity and especially ones that ripen from the top of the plant down, seed strippers are very effective. Some species have extremely indeterminate seed ripening and shatter easily upon maturity. Weed fabric can be used to suppress weed growth but also aid in seed harvest. Harvesting seeds of native wildflowers often takes a lot of creativity and a good fabricator. Aside from these methods, many other machines can be built to suit the needs of the average native seed producer. The most important factors to keep in mind when selecting a harvest method are the evenness of ripening and how easily the seeds shatter.

Seed Cleaning Research on Great Basin Forbs

Robert P. Karrfalt
USDA Forest Service, National Seed Laboratory, Dry Branch, GA, rkarrfalt@fs.fed.us

The Great Basin Native Plant Seed Increase Project has supplied funding and seeds to the National Seed Laboratory to develop efficient and cost effective seed cleaning protocols. Clean seeds are a great benefit in restoration work for several reasons. Clean seeds are sampled and tested for viability, purity, and seeds per kilogram with much higher accuracy that poorly or un-cleaned seeds. This in turn gives better control over sowing rates by giving accurate measurements of pure live seeds (PLS). Without knowing how many PLS are sown it is impossible to meaningfully assess germination and plant establishment success. Clean seeds also require much less volume in storage and, therefore, it is affordable to store them in well controlled environments that preserve viability for longer periods. Singularization and separation of seeds from stalks and fruits was accomplished using a Westrup Bruch machine. X-ray and microscopic examination showed that mechanical injury was minimal or none. Aspiration and screening removed most trash from extracted seeds. An indent cylinder was mostly successful in removing stems from the pure seeds. Finally a water activity meter was used to determine if seed moisture was low enough for long term storage of seeds.

Seed Conditioning of Understory Forbs in the Longleaf Pine Ecosystem

Jill Barbour[1]*, Jeff Glitzenstein[2], and Donna Streng[2]
[1]USDA Forest Service National Seed Laboratory, Dry Branch, GA, jbarbour@fs.fed.us;
[2]Tall Timbers Research Station, Tallahassee, FL

Restoration of longleaf pine ground layer vegetation needs a source of viable seeds. There is a general lack of basic information on seed cleaning, seed germination, long-term seed storage, and efficient procedures for nursery propagation. A U.S. Fish and Wildlife project began in 2006 between Tall Timbers Research Station botanists, Jeff Glitzenstein and Donna Streng, and the USDA Forest Service National Seed Laboratory to provide basic information on seed technology. Seeds from 25 forb species were hand collected in 2005 and 2006 from 6 sites within Alabama, Georgia, and South Carolina. Forb genera represented were *Amsonia*, *Aster, Baptista*, *Chamaecrista*, *Chrysopsis*, *Coreopsis*, *Eriogonum*, *Eupatorium*, *Galactia*, *Lespedeza*, *Liatris*, *Manfreda*, *Mimosa*, *Paspalum*, *Pityopsis*, *Tephrosia*, *Tetragonotheca*, and *Vernonia*. Seed conditioning and laboratory germination testing were performed and compared to nursery germination of seeds sown in August at the American Tree Seedling Nursery in Bainbridge, Georgia. In general, the laboratory germination was higher than the nursery germination except for *Mimosa*. Seed predation and high August temperatures were other reasons the nursery germination was less. For large scale nursery production, more efficient methods than hand cleaning are needed. The project is continued using

2007 seeds from 19 forbs genera from Georgia and South Carolina. Forb genera included are *Ageratina*, *Aster*, *Chrysopsis*, *Erythrina*, *Eupatorium*, *Galactia*, *Helianthus*, *Heliopsis*, *Liatris*, *Melanthera, Pityopsis*, *Tephrosia*, and *Vernonia*. Seed conditioning methods are compared against hand cleaning to determine the effect of machine cleaning on germination. Equipment includes a laboratory model Westrup brush machine, Forsberg scarifier, Stultz blower, General Blower, aspirator, Ideal indent cylinder, and hand held screens. Seeds, sown in containers in late autumn or winter in Tallahassee, Fla., were transported to the American Tree Seedling Nursery after initial germination to complete their seedling development.

Longevity of Native Wildflower Seeds

Christina Walters
USDA ARS, National Center for Genetic Resources Preservation, Fort Collins, CO, christina.walters@ars.usda.gov

Wildflowers and forbs used for production, plantings and restoration generally exhibit ‘orthodox’ storage behavior, meaning that longevity can be adjusted by balancing storage relative humidity and temperature. An RH of about 20 to 30% at the storage temperature provides optimum moisture conditions for maintaining seed viability. There is no one-protocol-fits-all circumstance, and good moisture control can be achieved using multiple strategies. These strategies must account for the difference between drying and storage temperature and fluctuations of storage temperatures, which are usually gleaned from RH-temperature-seed water content interactions described by water sorption isotherms. The longevities achieved by adjusting RH and temperature vary among species, with some seeds having relatively short life spans (e.g., *Allium* spp.) and some surviving for extended periods (e.g. *Abutilon* spp.). Seed aging occurs in two major phases, one that is asymptomatic and one with cataclysmic losses in seed viability. This biphasic kinetic has profound implications on the detection of aging and on genetic changes that occur in the sample during storage.

Seed Germination and Viability of Native Plants from the Intermountain West: Before and After Storage

Edward O. Guerrant Jr.
Berry Botanic Garden, Portland, OR, ed.guerrant@berrybot.org

Working with the Center for Plant Conservation, this study is part of a larger effort by the USDI Bureau of Land Management to develop native species for use in restoring public lands after large fires. Samples from 26 populations of 19 taxa were subjected to six different treatments to determine the best protocol for germinating each. Samples of 200 seeds each were initially cold stratified for zero, 8 or 16 weeks, then placed in a germination chamber maintained at a constant 20°C or one that fluctuated between 10°C and 20°C. Samples were then stored in one of two different sets of conditions, either in paper packets in cool (15°C), dry (22% RH) conditions, or, once equilibrated to the cool/dry conditions, stored frozen (-18°C) in waterproof metal-foil packets. After one and then two years storage, samples were then subjected to the single best treatment for each population in the initial trials. At the end of each trial, remaining seeds were subjected to a cut test, and the apparent viability of each was evaluated. The populations can be divided into four categories: 1.) high viability (>70%), high germination (>70%)(10 populations). 2.) high viability, medium germination (>40<70%)(7 populations); 3.) high viability, low germination (<40%) (6 populations), and. 4.) low germination and low viability (3 populations). The majority of populations (65%), those in the first two categories, show the greatest potential for use. About a quarter of the populations studied (23%) show potential for use if protocols can be developed to increase germination, and the remaining 12% appear to have low viability and thus little potential utility for restoration. Finally, three species are represented by three populations each, two from one ecoregion and the third from a different ecoregion. The results of these provide an initial glimpse into ecogeographic variation in germination requirements.

ABSTRACTS – Poster Presentations

An Ecoregion-based Approach to Development of Genetically Diverse Germplasm for Native Willamette Valley Prairie Species

Melanie Gisler, Kimiora Ward*, and Rob Fiegener
Native Seed Network, Corvallis, OR, melanie@nativeseednetwork.org

We are developing a supply of ecologically appropriate, genetically diverse native plant material for restoration of wetland and upland prairie ecosystems of the Willamette Valley ecoregion. Our approach seeks to achieve a balance between capturing maximum genetic diversity of restoration germplasm and protecting genetic integrity of extant native populations. We chose 17 historically widespread, common species for increase, and worked within a climatically uniform geographic area, the Willamette Valley ecoregion. We defined seed transfer zones for each species based on literature review of their breeding system, potential for hybridization, polyploidy, taxonomic uncertainty, outbreeding depression and local adaptation. Species with evidence for local adaptation at a spatial scale smaller than the ecoregion were either eliminated from the program or included with a conservative seed-combining approach. Morphometric and DNA analysis of population variation guided development of seed transfer zones for the highly variable species, *Sidalcea campestris* (meadow checkerbloom). Within a seed transfer zone, we captured spatial and temporal genetic diversity by sampling from up to 20 populations per species across the geographic range of the ecoregion over a two-year period. To minimize genetic shifts or loss of diversity through “domestication selection”, we planted increase fields using a novel approach, the Diversity Enhancement Block design. In this planting design, G0 seed lots from different areas within the ecoregion were planted in separate but adjacent blocks. We used this approach with species that were suspected to have geographic variability for phenology, but had no known genetic issues whereby cross pollination would be undesirable. The Diversity Enhancement Block design allows farmers to harvest each block separately (as seeds mature), while still permitting plants from different regions of the Valley to cross-pollinate and, theoretically, produce G1 seeds with maximum genetic diversity.

Mississippi Wildflower Seed Program – A Partnership between the USDA NRCS Jamie L. Whitten Plant Materials Center and the Mississippi Soil and Water Conservation Commission

Janet Grabowski[1]* and Thomas Moss[2]
[1]USDA NRCS, Brooksville Plant Materials Center, Brooksville, FL, janet.grabowski@fl.usda.gov; [2]USDA NRCS, Jamie L. Whitten Plant Materials Center, Coffeeville, MS

In 1996, the Mississippi Legislature authorized implementation of the Wildflower Seed Revolving Fund. This fund was created to allow the Mississippi Soil and Water Conservation Commission (MSWCC) to acquire wildflower seeds produced by the USDA-NRCS Jamie L. Whitten Plant Materials Center (PMC), thus establishing the Native Wildflower Conservation Program. This program allows the Soil and Water Conservation Districts within the state to distribute wildflower seeds to the public and acts as a source of funding for the districts. It also allows seed production costs to be returned to the PMC to supplement funds received for operating costs and has provided invaluable experience in seed production techniques, such as establishment methods, harvesting and seed cleaning requirements, for those wildflowers in the program. Currently 6 species are in large-scale field production, with 2 additional species in smaller production blocks. All wildflowers were originally collected from Mississippi populations and are often more suitable than seeds available from non-local commercial producers.

Seed Stripper Harvest Rates for Native Wildflowers

John P. Morgan
Prairie Habitats Inc., Argyle, MB Canada, jpmorgan@mts.net

Harvesting large volumes of diverse species of wildflower seeds for restoration projects often is time-consuming, difficult and labor-intensive. Equipment used for harvesting also may negatively impact the ecosystem remnant or natural area supplying the seeds. Those requiring native wildflower seeds typically do not have the time, expertise or resources to custom-built harvesters for each project. Portable seed stripper harvesters offer a way to harvest fairly large volumes of wildflower seeds efficiently with little impact on the seed production sites. They also can adapt to many different species in ecologically sensitive areas and are easy to use and maintain. Seed stripper harvest rates for over 55 species were recorded in wild stands in Manitoba, Canada and other countries from 1989 to 2006 and are reported in this paper. Portable seed strippers are one tool wildflower seed producers can use effectively for native species harvesting in a wide variety of wild and nursery harvest conditions.

Screening Herbicides for Use in Native Wildflower Seed Production in the Intermountain West

Clinton C. Shock[1]*, Joey Ishida[1] and Corey V. Ransom[2]
[1]Oregon State University Malheur Experiment Station, Ontario, OR, clinton.shock@oregonstate.edu; [2]Department of Plants, Soils, and Biometeorology, Utah State University, Logan, UT

Native wildflower seeds are needed to restore rangelands of the Intermountain West. While commercial seed production is necessary to provide the quantity of seeds needed for restoration efforts, a major limitation to economically viable commercial production of native wildflower seeds is weed competition. Commercial wildflower seed production typically occurs on cultivated cropland. Weeds are adapted to growing in disturbed, cultivated soil, and native wildflowers are often not competitive with these weeds. There is a considerable body of knowledge about the relative efficacy of different herbicides to control target weeds, but few trials have tested native wildflowers for their tolerance to commercial herbicides. Field trials tested the tolerance of 7 native wildflower species (*Eriogonum umbellatum, Penstemon acuminatus, P. deustus, P. speciosus, Lomatium dissectum, L. triternatum, and L. grayi)* to conventional preemergence and post emergence herbicides at rates typically used in crop production, seeking to discover products that could eventually be registered for use for native wildflower seed production. Wildflower herbicide tolerance varied by specie. Tolerance to preemergence herbicides was highly variable. Tolerance to post emergence herbicides was variable, but uniformly fairly good with few noticeable effects when evaluated a year after application.