Ornamental Plants and the U.S. National Plant Germplasm System: Conserving, Evaluating, Seeking, and Sharing

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INTRODUCTION

Genetic diversity is a key component of stable agricultural production in a rapidly changing world. The genetic variation found in field crops, fruits, vegetables, ornamentals, other economically important plants, and their wild and weedy relatives is crucial for crop improvement and the development of new agricultural products. This diversity is found both in nature and in traditional agricultural systems. However, both natural plant communities and traditional agriculture face many threats and are being extensively replaced through urbanization, habitat degradation, and the rise of modern agricultural systems that are based on a relatively narrow genetic base.

Throughout the world, plant genebanks have been established to sample and conserve significant components of this genetic diversity and make them readily accessible. This is typically done under controlled conditions, away from natural plant communities or traditional systems, which present both efficiencies of scale and challenges (when optimal growing conditions cannot be easily re-created). Considerable emphasis has generally been placed on major crops that feed the world, but, collectively, the world's genebanks do conserve a remarkably wide array of plants.

The United States Department of Agriculture (U.S.D.A.) supports the National Plant Germplasm System (NPGS), one of the world's most extensive national genebank networks. The NPGS includes more than 20 locations (active sites with curators), administered and coordinated by the U.S.D.A. — Agricultural Research Service in collaboration with the U.S.D.A.'s Cooperative State Research, Education and Extension Service, and the State Agricultural Experiment Stations and Land-grant Universities (Bretting, 2007). The NPGS locations encompass a broad range of growing conditions from high latitude to tropical and from arid to very wet. And just as the sites represent many environments, they also conserve many different types of plants, including those of interest to IPPS members (see Table 1 for a list of pertinent locations). Of those sites, the two with the largest collections directly focusing on ornamental horticulture are the Ornamental Plant Germplasm Center at Ohio State University (Tay et al., 2004) and the Woody Landscape Plant Germplasm Repository at the National Arboretum.

GERMPLASM CONSERVATION

The NPGS has a long-term outlook, seeking to preserve both agricultural plant biodiversity, in the form of plant collections (often managed by genus) made up of distinct accessions, and the documentation associated with it. The overall goal is to make these collections and associated information widely available in support of research and education. Accessions include both clonal selections and seed-propagated populations. For clonal selections, NPGS curators employ many of the same techniques as used by commercial propagators to ensure plant health and

genetic integrity (Postman et al., 2006). These include virus indexing and the use of isolation chambers for the exclusion of disease vectors, budding, grafting, stooling, layering, the rooting of cuttings, and the preservation of tissue cultures in vitro. Often, clones are cultivated on site in long-term field plantings.

For seed-propagated populations, a curator's choice of techniques depends strongly on the plant's pollination biology and its breeding history (e.g., a uniform inbred line would not need nearly as large a population sample as would a diverse, outcrossed landrace of the same species) (Sackville Hamilton and Chorlton, 1997). Hand-pollination, isolation by space and/or time, and screened cages containing pollinating insects (Widrlechner et al., 1997) are all used for seed production. The seed samples are typically held on site under controlled temperature and humidity conditions, generally at or below 4 °C.

Collections that are held only at a single site are vulnerable to accidental loss or disaster. To reduce these risks, NPGS collections are intentionally backed-up at other locations, typically at the National Center for Genetic Resources Preservation (NCGRP) in Fort Collins, Colorado, a stop on one of the Denver meeting's tours. Most seed samples are stored either in conventional freezers or under cryogenic conditions in tanks with liquid nitrogen. The NCGRP has also worked with the active sites to develop techniques for the cryogenic storage of clonal materials, investigating both dormant buds (Forsline et al., 1998; Towill and Widrlechner, 2004) and vitrified in vitro cultures (Towill and Bonnart, 2003).

Describing Collections. The value of germplasm collections is closely connected to the information that is known about them. Three basic classes of information can be linked to each accession in a collection. First is "passport data." This is the information that should accompany an accession when it is acquired, describing where it came from in terms of geography and, for cultivated plants, its cultural and/or breeding history. Often, it also includes site-specific information describing local environmental conditions, uses, and other observations made at the time of collection.

Next is "characterization data." This class includes data describing highly heritable traits that can be used to verify accession identity at many different levels, from verifying the species all the way down to meeting a cultivar description or generating a molecular fingerprint of it. And finally, there is "evaluation data." Accessions can be evaluated for their responses to abiotic and biotic stresses, for chemical composition, for phenological (timing and developmental) traits, for yield in crops, or for landscape performance and aesthetics. These evaluations ideally are conducted under well-defined conditions, often at multiple locations, because plant responses for such traits result from interactions between genetic control and environmental variation. A good example of such an evaluation program for woody landscape plants is the NC7 Regional Ornamental Plant Trials, a long-term, multisite network focused on the performance of new trees, shrubs, and vines for the North Central United States (Widrlechner, 2004).

Passport information for NPGS collections goes back to the days of the Bureau of Plant Industry with the publication of the first volume of USDA Plant Introductions in 1898. Increasingly, characterization and evaluation data are being generated on these collections both by NPGS staff and many collaborators, enhancing the value of collections to users (Day Rubenstein et al., 2006). Many of these efforts are

coordinated by 40 crop-specific Crop Germplasm Committees (CGCs), representing diverse users in academia, industry, and government. The Herbaceous Ornamental CGC and the Woody Landscape Plant CGC (Robbins et al., 2008) are two CGCs of primary interest to IPPS members.

All these kinds of information, along with numerous images in support of characterization and evaluation, are maintained the NPGS's comprehensive database, the Germplasm Information Resources Network (GRIN). The GRIN database is accessible on the Internet <http://www.ars-grin.gov/npgs>, allowing searches for information that can then be linked to germplasm requests. The GRIN databse is expanding the scope of information held, with recent advances in both molecular genetic data (Volk and Richards, 2008) and geo-referencing.

Building Collections. The NPGS curators work with many collaborators throughout the world, seeking new accessions to fill gaps in existing collections. For well-established collections, such efforts often focus on poorly represented geographic regions and/or landraces, or on wild relatives. A good example of a shift in emphasis towards collecting wild relatives has occurred over the last 20 years in the *Helianthus* collection, where the relevant curator and CGC have plans to sample all the known 60+ species in the genus. In contrast, many NPGS collections of ornamental plants, both herbaceous and woody, are relatively shallow, with holdings of few ornamental genera exceeding 100 accessions. In such cases, many recent efforts to acquire new ornamental plants focused on the collection of multiple genera from regions relatively rich in species diversity or in those areas with environmental conditions that should be reflected in tolerance to abiotic stresses. However, targeted efforts specific to one or a few ornamental genera are also being conducted by the NPGS, such as work that I am coordinating to expand the *Fraxinus* collection in the face of emerald ash borer and a project to acquire native *Rudbeckia* and *Coreopsis* populations at the Ornamental Plant Germplasm Center.

The NPGS supports this "seeking process" through a granting program coordinated by its Plant Exchange Office, which reviews and recommends funding for exploration proposals. The Plant Exchange Office facilitates both domestic and international exploration (Williams, 2005). Since the advent of the Convention on Biological Diversity (CBD), which applies generally to the international exchange of ornamental-plant germplasm in nearly all nations, NPGS-supported explorations outside of the U.S.A. have become much more challenging. Many countries place restrictions on the sharing of germplasm originating from within their borders that run counter to the NPGS policy of freely sharing its collections in support of research and education.

Sharing Collections. I'd like to close this overview of the NPGS by focusing on sharing, in other words, the distribution of collections, with an emphasis on ways that NPGS collections (Table 1) may be particularly useful to IPPS members. Distribution is an important aspect of all NPGS active sites as the value of its collections is realized through their use. The NPGS distributes its collections quite widely to meet external requests in support of research and education. In recent years, about 120,000 samples have been distributed annually, with about 75% to domestic users (Bretting, 2007). The GRIN database simplifies the distribution process by providing users with easy access to information about germplasm availability and an on-line form to request samples.

The NPGS does not compete with commercial nurseries or seed companies. External requests for germplasm that would be better met by commercial sources are referred by NPGS curators to appropriate suppliers. But there are many ways that NPGS collections can support the work of propagators and the firms, academic organizations, and gardens that employ them. I will mention four in particular.

The first is in the selection and breeding of new taxa of ornamentals. While many accessions may not be directly useful as new introductions, they may contain special genes that confer useful traits to progeny in breeding. This is a common use for germplasm collections in a wide range of highly bred agronomic and horticultural crops. A good example in shade-tree breeding is the *Pyrus* program based on crosses among germplasm from the NPGS site in Corvallis, Oregon coordinated by the Landscape Plant Development Center (Hummel, 2000, 2007).

The second is for reintroducing useful species or cultivars that have been lost from commerce but have been conserved in NPGS collections. The nursery trade is dynamic, and many ornamentals are dropped from catalogs because of short-term production problems, cyclical change in popularity, or the introduction of new cultivars that are purported to be superior to the one being discontinued.

The third is to serve as a well-documented source to serve as foundation stock in cases where there is confusion over the true identity of a cultivar in the trade. In cases where the history of an NPGS clonal accession can be traced to the originator, this can be especially helpful.

And finally, is the use of NPGS collections in experiments where one would like to be able to repeat the results over time. When experiments and their results are presented in scientific papers for publication, journal editors typically request that authors describe their materials and methods in such detail that the experiment can be independently repeated. The degree of documentation associated with NPGS accessions and the NPGS's goal of preserving the genetic make-up of each accession as it is received, work together to make NPGS accessions particularly good "guinea pigs" for plant-propagation research, especially as standard check or control taxa.

I hope that these remarks shed some new light on the NPGS and how its collections are consistent with the IPPS motto: "To Seek and To Share."

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LITERATURE CITED

Bretting, P.K. 2007. The U.S. National Plant Germplasm System in an era of shifting international norms for germplasm exchange. Acta Hort. 760:55–60.

Day Rubenstein, K., M. Smale, and **M.P. Widrlechner.** 2006. Demand for genetic resources and the U.S. National Plant Germplasm System. Crop Sci. 46:1021–1031.

Forsline, P.L., L.E. Towill, J.W. Waddell, C. Stushnoff, W.F. Lamboy, and **J.R. McFerson.** 1998. Recovery and longevity of cryopreserved dormant apple buds. J. Amer. Soc. Hort. Sci. 123:365–370.

Hummel, R.L. 2000. Update on Washington State University Puyallup *Pyrus* (pear) hybrids. Landscape Plant News 11(3):7–9.

Hummel, R.L. 2007. Searching for the next 'best tree': Why timing is essential! Landscape Plant News 18(2):2–3.

Postman, J., K. Hummer, E. Stover, R. Krueger, P. Forsline, L.J. Grauke, F. Zee, T. Ayala-Silva, and **B. Irish.** 2006. Fruit and nut genebanks in the U.S. National Plant Germplasm System. HortScience 41:1188–1194.

Robbins, J., M. Widrlechner, R. Olsen, S. Reed, A. Meerow, K. Hummer, P. Bretting, P. Allenstein, and **M. Krautmann.** 2008. Gene banks offer breeders access to germplasm: Germplasm collections help to preserve genetic diversity. Nursery Mgt. Prod. 24(5):53–56, 58.

Sackville Hamilton, N.R., and **K.H. Chorlton.** 1997. Regeneration of accessions in seed collections: A decision guide. Handbook for Genebanks 5. IPGRI, Rome, Italy.

Tay, D., M.P. Widrlechner, and **J.L. Corfield.** 2004. Establishment of a new genebank for herbaceous ornamental plants. FAO/IPRGI Plant Genetic Resources Newsletter 137:26–33.

Towill, L.E., and **R. Bonnart.** 2003. Cracking in a vitrification solution during cooling or warming does not affect growth of cryopreserved mint shoot tips. CryoLetters 24:341–346.

Towill, L.E., and **M. Widrlechner.** 2004. Cryopreservation of *Salix* species using sections from winter vegetative scions. CryoLetters 25:71–80.

Volk, G.M., and **C.M. Richards.** 2008. Availability of genotypic data for USDA-ARS National Plant Germplasm System accessions using the Genetic Resources Information Network (GRIN) database. HortScience 43:1365–1366.

Widrlechner, M.P. 2004. Insights into woody plant adaptation and practical applications. METRIA Proc. Vol. 13. <http://www.ces.ncsu.edu/fletcher/programs/nursery/metria/metria13/widrlechner/>

Widrlechner, M.P., C.A. Abel, and **R.L. Wilson.** 1997. Ornamental seed production in field cages with insect pollination. Comb. Proc. Intl. Plant Prop. Soc. 46:512–516.

Williams, K. 2005. An overview of the U.S. National Plant Germplasm System's exploration program. HortScience 40:297-301.

Table 1. Active sites in the National Plant Germplasm System of interest to IPPS members: Name, Location, and Crop Type (in parentheses)[1].

National Clonal Germplasm Repository – Corvallis, OR (F&N)
National Clonal Germplasm Repository for Citrus and Dates – Riverside, CA (F&N)
National Clonal Germplasm Repository for Tree Fruit / Nut Crops and Grapes – Davis, CA (F&N)
North Central Regional Plant Introduction Station – Ames, Iowa (WLP, HO)
Ornamental Plant Germplasm Center – Columbus, Ohio (HO)
Pecan Breeding & Genetics – Brownwood and Somerville, Texas (F&N)
Plant Genetic Resources Conservation Unit – Griffin, Georgia (WLP, HO)
Plant Genetic Resources Unit – Geneva, New York (F&N)
Subtropical Horticultural Research Station – Miami, Florida (TF&N, TO)
Tropical Agriculture Research Station – Mayagüez, Puerto Rico (TF&N, TO)
Tropical Plant Genetic Resource Management Unit – Hilo, Hawaii (TF&N)
Western Regional Plant Introduction Station – Pullman, Washington (HO, WLP)
Woody Landscape Plant Germplasm Repository – Washington, D.C. (WLP)

[1]F&N: fruits and nut genera; HO: herbaceous ornamentals, TF&N: tropical fruit and nut genera, TO: tropical ornamentals. WLP: woody landscape plants.