The US National Plant Germplasm System: the Ornamental Plant Germplasm Center

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Abstract

The US National Plant Germplasm System (NPGS), under the auspices of the US Department of Agriculture (USDA) is the national plant genebank system. The NPGS is a cooperative effort between public (State and Federal) and private organizations. There are currently some 24 active seed and clonal repositories distributed throughout the country and a long-term genebank for base collection at the National Center for Genetic Resources Preservation (NCGRP) in Fort Collins, Colorado. Currently, the more than 450,000 accessions are mainly of food, fiber and industrial crops and only about 3,000 accessions are herbaceous ornamental plants. There is a critical need for a repository to take on this important task and the establishment of the new NPGS Ornamental Plant Germplasm Center (OPGC) at The Ohio State University (OSU) marked the beginning of this effort for the first time in the world. An appraisal of the priority genera list (30 genera) formulated by the USDA Herbaceous Ornamental Crop Germplasm Committee was attempted. The genebanking management procedure was illustrated. Networking and cooperation models between the Center and the horticultural and seed industry, botanic gardens and arboreta, crop specific societies, seed savers groups and individuals are presented.

Introduction

Plant genetic resources or plant germplasm are the genetic variability that plant breeders use to breed new crop cultivars. These genetic materials comprise of our landraces, traditional or heirloom varieties, wild and weedy forms, related wild species, genetic stocks, inbred lines and even our modern cultivars. The genetic materials include individual genes and their alleles, linkage of genes, epitastic sets of gene combinations, combination of different genomes by the addition of a whole set of chromosomes or a lack of whole chromosomes, etc. In the new era of gene identification, isolation and gene transfer the genes that are used in transformation are derived from germplasm that exists in nature. The conservation of plant germplasm therefore becomes even more crucial and important. This can be attributed to three main reasons: (1) the gene transformation technologies have allowed us to introduce gene of one species into that of another i.e. the gene pool boundary of a species has expanded to encompass other organisms. This calls for the collection and conservation

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of a wider range of species to capture greater diversities; (2) the rapid adoption of the modern transformed cultivars with wider and better adaptation is hastening the replacement our conventional cultivars i.e. causing increasing genetic erosion; and (3) the accelerating rate of urban expansion and human disturbance in our natural environment is causing displacement of our plant genetic diversities. For example, African violet, *Saintpaulia* sp. is an endangered genus in its natural habitats in East Africa because of urban and farm development.

Plant genetic resources conservation has developed into a discipline in the last half a century with primary focus on food, fiber and industrial crops. Sophisticated facilities known as genebanks with cold storage rooms at -18°C for storing seed and cryo-preservation tanks with liquid nitrogen at -196°C for storing seed, tissue cultures and buds, have been developed. The genebanks at national programs and the international crop research institutions of the Consultative Group on International Agricultural Research (CGIAR) are globally storing an estimated 6.1 million accessions of our food, fiber and industrial crops (FAO, 1998) and very few of them are of ornamental plants. The CGIAR has no mandate for ornamental species and similarly, most national programs have no priority in ornamentals. The conservation of flower germplasm is left to botanical gardens and arboreta, and private collections of plant nurseries, seed companies and individuals.

The global floriculture industry was valued at US$50 billion dollars in 1995 with 31 billion dollars in cut flowers and 19 billion dollars in potted plants (de Groot, 1998). In U.S.A. the annual wholesale value of nursery and floral crops in 2001 was $4.74 billion, representing a 4% increase over 2000 (USDA, 2002). The size and rapid rate of development of this sector indicate a critical need to collect, conserve and utilize ornamental plant germplasm to sustain the expansion of the industry.

Since most ornamental plant improvement programs concentrate on aesthetic qualities such as flower and plant characteristics, the genetic base of our modern cultivars is becoming more and more narrow. For example, the hundreds of impatiens, pansy, petunia and marigold cultivars of the major international flower seed companies are quite alike. Coupling with global marketing and the adoption of these cultivars worldwide, many heirloom varieties of these crops and other ornamental crops are being replaced by modern narrow genetic base cultivars, resulting in continuing loss of our traditional heirlooms and causing serious genetic erosion. An herbaceous ornamental plant genebank is therefore crucial to collect and conserve the disappearing heirlooms, to explore, collect and conserve new genetic materials and species with other than just aesthetic characteristics, and to evaluate and distribute these germplasm.

The US National plant germplasm system

The US National Plant Germplasm System (NPGS) is the national plant genebank system. The NPGS decentralized ex situ genebank network has some 24 seed and clonal repositories scattered all over the country from Mayaguez, Puerto Rico in the east and south to Hilo, Hawaii in the west and Palmer, Alaska in the north, and the long-term storage facility for base collection at the National Center for Genetic Resources Preservation (NCGRP) in Fort Collins, Colorado (Figure 1). It is a joint effort by public (State and Federal) and private organizations to preserve plant genetic diversity. In 1981 the National Workshop on Plant Germplasm held at Peoria, Illinois developed

this NPGS mission statement – "The National Plant Germplasm System (NPGS) provides the genetic diversity necessary to improve crop productivity and to reduce genetic vulnerability in future food and agriculture development, not only in the United States but for the entire world. The NPGS acquires, maintains, evaluates, and makes readily accessible to plant scientists a wide range of genetic diversity in the form of seed and clonal germplasm of crops and potential new crops." Documentation is also an important part of NPGS and to-date this statement applies.
The 1946 Farm Bill which created the Plant Introduction System marks the beginning of NPGS. Four Regional Plant Introduction Stations were established in Geneva, New York (NE9), Ames, Iowa (NC7), Griffin, Georgia (S9) and Pullman, Washington (W6). In 1958, the National Seed Storage Laboratory (present NCGRP) was dedicated for long-term preservation of accessions as base collection. In the 1980s clonal repositories for conserving vegetatively propagated species were established and at NCGRP seed were first stored in liquid nitrogen vapor phase. Later, pollen, dormant temperate fruit buds and recalcitrant seed were also cryo-preserved in liquid nitrogen in the late 1980s and early 1990s. The expansion of NCGRP was completed in 1992. The latest addition to NPGS is the Ornamental Plant Germplasm Center (OPGC) in collaboration with the Ohio State University in 1999.

The NPGS currently maintains more than 450,000 accessions of 4,474 plant species, the largest collection in the world. The repositories are mandated to curate the genera that are most suitable to be maintained based on their climatic conditions in both seed and clonally propagated species. Except for NCGRP, all the repositories are active sites with medium-term seed storage facilities and in vitro laboratories for the preservation of clonal materials. Plant germplasm are acquired through these active sites and the collected germplasm are multiplied and stored, characterized and evaluated, documented and distributed to researchers and for long-term storage at NCGRP. The number of germplasm accessions maintained at the NPGS stations is summarized in Table 1.

The NPGS is managed by the USDA Agricultural Research Service in Beltsville, Maryland. It has a National Program Leader who administrates the funding and ensures that the national policies and procedures are abided. The repositories are linked together by the Germplasm Resources Information Network (GRIN) which is managed and maintained by the National Germplasm Resources Laboratory (NGRL) in Beltsville, Maryland. The NGRL also operates a Plant Exploration Office and a Plant Introduction Office. These units provide coordination between the repository's curators and their counterparts in other countries to ensure that the national policies, laws and regulations are followed and vice versa. The GRIN is a web-based databases system that is designed and written by NGRL. It is used by crop curators to input germplasm information such as passport, characterization and evaluation data and seed storage data such as store inventory and seed quality. The end-users can request germplasm by GRIN from anywhere in the world using internet (http://www.ars-grin.gov).

The NPGS invites experts from universities, industries and USDA and other related organizations to form Crop Germplasm Committees (CGCs). All major crops have their own CGCs and there are currently 40 such committees (Table 2). The role of a CGC is advisory, consultative and supportive, and its includes germplasm identification in relation to acquisition, weakness and gaps in a collection; recommendation in crop descriptors and evaluation methodologies; regeneration techniques and any recommendation to increase the value of a collection such as the use of GIS and

DNA technologies, etc. It also plays an important role in communication and as inter-phase between researchers of a crop with its targeted industry. This system provides a mean for end-user representations and feedback on a collection such as viability and quality of accessions received, report on the usefulness of the germplasm, contribution to published research, etc. The relationship of a CGC to a repository is further illustrated in the section on OPGC, latter.

The NCGRP has the state of the art long-term storage facilities equipped with both -18°C cold vaults for preserving seed and -196°C cryopreservation tanks with liquid nitrogen (or -160°C in the vapor phase) for seed and plant propagules in base collections. The mission of its Seed Viability and Storage Research Unit is "to effectively document, preserve and maintain viable seed and propagules of diverse plant germplasm in long-term storage, to develop and evaluate procedures for determining seed quality of accessions, and to provide administrative support to allow for effective operation of the Unit. The mission also includes the distribution of seed, when not available from the active collections, for crop improvement through out the world." All the active repositories with mandate to preserve seed have medium-term seed storage cooler facilities operating at 2-5°C and below 40% relative humidity. The clonal repositories and other sites that have mandate for clonal materials are equipped with tissue culture facilities.

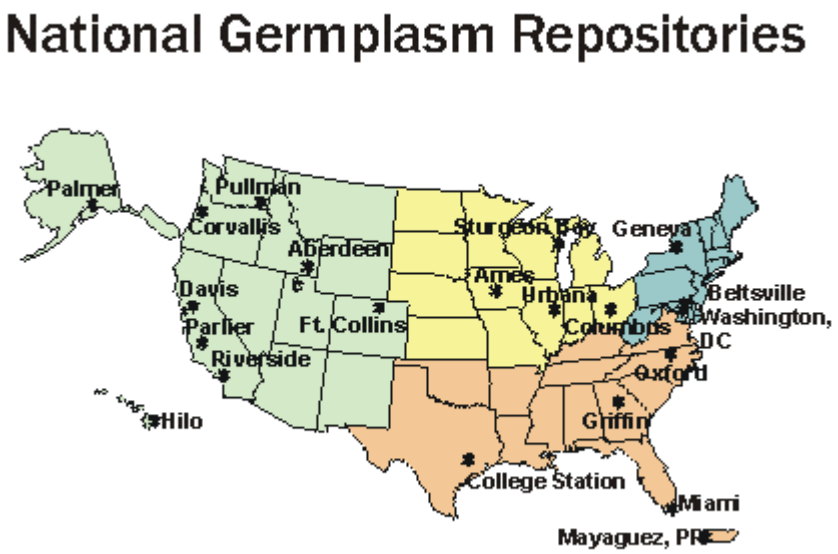

Figure 1: The location of NPGS germplasm repositories in the country

The Ornamental Plant Germplasm Center

There are only about 3,000 accessions of herbaceous ornamental plants in NPGS, representing only 0.7% of the total 450,000 accessions in the whole collection. The need for a specialized genebank dedicated specifically to herbaceous ornamental crops has been elaborated above. This was strongly advocated by the American floricultural industry (GMPRO, 1999). In August 1999, an agreement to establish the Ornamental Plant Germplasm Center (OPGC) jointly by USDA and The Ohio State

University (OSU) in Columbus, Ohio created the first such genebank (See http://hcs.osu.edu/opgc for more information). It became the most recent germplasm repository of NPGS.

The OPGC's mission is "to salvage and nurture the world wealth of herbaceous ornamental plant diversity by systematically saving, assessing and using it to bring happiness and health to humankind and to promote awareness in herbaceous ornamental crop germplasm conservation". The OPGC was inaugurated in July 2001. The goal is to build OPGC into a world's leading herbaceous ornamental plant genebank and a "center of excellence" in flower germplasm conservation and research, which is currently lacking in the world. The OPGC will benefit the floriculture industry and consumers by making available unique genetic materials essential for the improvement of our present and future flower crops. The following objectives were formulated to achieve this goal and fulfill the functions mentioned above:

- To establish an herbaceous ornamental plant genebank as an integrated component of NPGS;
- To build a network of cooperators from the horticultural industry, universities, USDA, botanic gardens and arboreta, crop specific societies and individuals;
- To establish a system that promotes industry oriented collaborative research to enhance germplasm utilization; and
- To institute academic programs and industrial short courses in germplasm conservation of flowers.

Its main functions can thus be categorized into three areas as follows: (1) germplasm service provider including germplasm acquisition, conservation, characterization, evaluation, enhancement of utilization, documentation and distribution, (2) flower germplasm and conservation research to facilitate the development of more efficient and effective germplasm management systems, new techniques to conserve seed and clonally propagated germplasm, and germplasm enhancement, and (3) flower germplasm education and training to fulfill the lack of specific training in this field.

Relationship Between OPGC and USDA

The OPGC is formed by an US Government's Special Cooperative Agreement between USDA and OSU and it is a unique collaboration where a national repository is administered and implemented directly by the collaborating University. As a repository of NPGS, OPGC is managed and operated under NPGS germplasm guidelines, procedures and conducts, and all major operational matters are carried out in consultation with USDA. The Center works closely with the USDA Herbaceous Ornamental Crop Germplasm Committee (HOCGC) that provides guidance and recommendations on technical issues relating to the Center's mandate, and OPGC participates in all NPGS activities. The HOCGC consists currently of 37 prominent US floriculturists and researchers from the flower seed companies, plant nurseries, universities, USDA, botanic gardens and arboreta (see http://www.ars-grin.gov/cgi-bin/npgs/html/mbrship.pl?HERBACEOUS). Within HOCGC there is a subcommittee for the Center. This organizational relationship between OPGC and USDA is summarized in Figure 2.

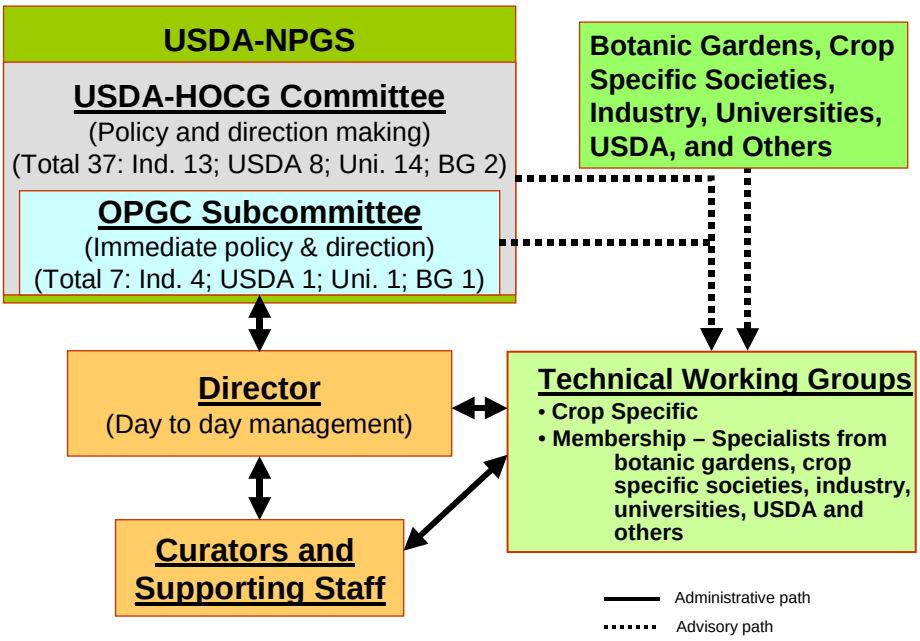

Figure 2: Organization relationship between OPGC and USDA

Strategic plant and technical considerations

The following technical considerations were assessed in the preparation of the OPGC strategic plan:

- The many species and variants in herbaceous ornamental plants - heirloom cultivars, landraces, obsolete, wild relatives, genetic stocks, hybrid complexes, polypoidy series, etc.;
- The lack of stable taxonomy and unclear evolutionary relationships;
- The wide geographical distribution, diverse center of origin and diversity, and lack of information on genetic erosion;
- The lack of information on sexual and asexual propagation and conservation:
  - Seed germination, production, seed technology and storage methods
  - Tissue culture and cryopreservation methods;
- Plant quarantine requirements in introduction and distribution;
- Duplicate identification, formulation of crop descriptors, prioritizing traits for evaluation, and DNA fingerprinting & marker technologies; and
- Establishment of Core collections.

Flowers encompass a vast number of plant genera and species from all climatic regions of the world. While many of them have thousands of years of domestication history, equally many new species are being evaluated and introduced into our gardens. Large numbers of cultivars and variants have been bred and maintained for some genera. For example, the American *Hemerocallis* Society up to

Year 2000 had registered some 48,538 entries and about half are still maintained and available. A similar situation exists for clonally propagated genera such as *Begonia*, *Iris*, *Lilium*, *Narcissus* and *Pelargonium*, where the establishment of a set of criteria to select a "core" collection of each species in order to capture the maximum amount of genepool of the genus. The criteria commonly considered are species representation, geographical distribution, ecological factors e.g. soil, altitude, latitude, drought, frost and micro-climate, specific genes such as disease and pest resistance genes, cultural input efficient gene, aesthetic genes, etc. The conservation strategy to maintain a "core" collection depends on the genetic materials as follows:

- For wild related species – use seed of individual accessions
- For seeded traditional cultivars – use seed of individual accessions
- For seeded modern cultivars – use seed of polycross within groups
- For non-seeding species – use in vitro and live plants
- For non-seeding traditional cultivars – use in vitro and live plants

In every cycle of seed multiplication and storage some changes in the genetic composition or loss in genes of an accession causes genetic erosion in a genebank. When the number of accessions for seed regeneration increases and accumulates in a genebank, a decision has to be made to take these accessions as quickly as possible into safe storage. A good plant genetic resources conservation program is one where all the wanted accessions are regenerated with an acceptable genetic and seed quality as compared to another where only a portion of the wanted accessions is regenerated with very high quality seed, but some of the wanted accessions are lost completely.

Based on the needs of the floriculture industry, the technical considerations above and the project resources available a three-phase strategic development plan was formulated as shown below.

Establishment Phase (2001-2002)
• Building infrastructure
• Building team – staff and external networking
• Setting Priority – consultation, survey and literature review
• Launching germplasm introduction and accessioning

Development Phase (2002-2004)
• Evaluating progress and the "SHOCKER" analysis (see below for reference)
• Perfecting genebanking techniques
• Expanding team building, staff development & graduate assistantships
• Seeking R&D funds
• Formulating a manageable OPGC program

Operational Phase (2004 onward)
• Running a predictable yearly program, including services and training activities with flexibility to introduce new activities
• Continuing to seek R&D funds and maintaining cooperator and clientele base

This is the beginning of its second year operation and the progress is as planned. A strategic planning session was done recently to formulate an implementation plan for the coming two years. Team building through networking is of top priority. Strong working relationships with both public

and private sector researchers and plant breeders are being identified and developed. A proposed networking model is shown in Figure 3.

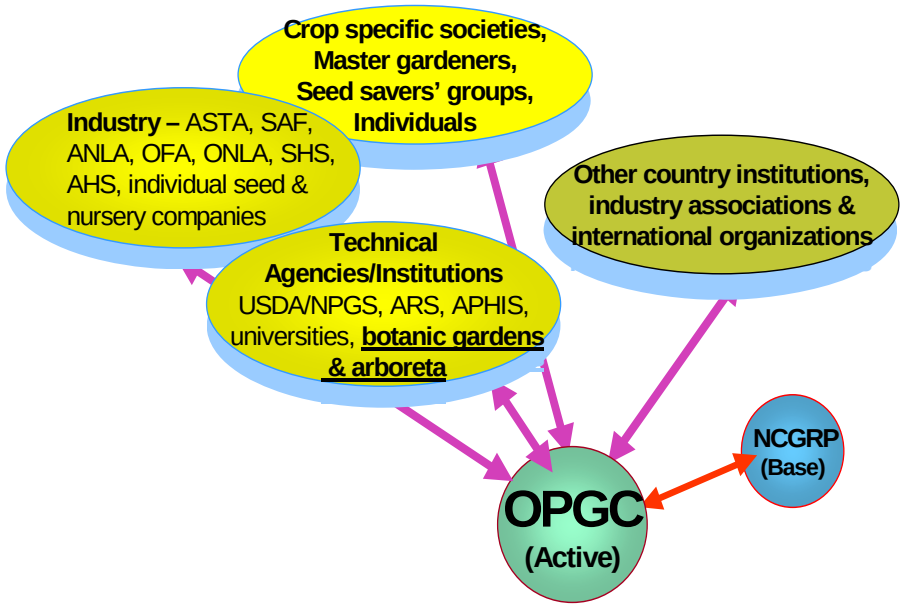

Figure 3: The OPGC Networking Model

Genebank Infrastructure

The OPGC building was built ten years ago as a bio-containment facility to quarantine ornamental plant introduction at the OSU Columbus Campus and it was remodeled for use as a genebank in this project. The 550 m2 building currently consists of a 25,000-accession capacity medium term seed storage cooler, provision for a tissue culture laboratory to conserve in vitro collection, a flower seed research laboratory and a seed processing plant. Adjoining the building is a 1,060 m2 two-row computerized environment-controlled greenhouse complex for year round seed regeneration and research work. The specialized herbaceous ornamental seed research laboratory is equipped with a thermo-gradient germinator, two accelerated aging water-jacket incubators, four germinators, a custom-built single-seed weight sorting machine, a STS-MACS four-channel aspirator, a KA-K gravity separator, a LA-H Laboratory Brush Machine, single deck vibratory seed separator, a Clipper Office Tester & Cleaner, a belt thresher, a seed scarifier, a STS-1B-30C Cabinet system dryer and a STS temperature and time controlled precision dryer.

The core of the building is the seed storage cooler which is operating at 2-5°C and around 30% r.h. This combination of temperature and r.h. regime allows seed to be stored and dried down to low

seed moisture content of 5-7% (wet basis) and for most "orthodox" seed a storage life of 10-15 years is quite standard. The cooler therefore also functions as a slow dryer which is gentle to seed during drying. The seed processing facilities were planned to provide a free-flowing production line system to transfer seed into the cooler.

A tissue culture laboratory will be set up for the maintenance of clonally propagated germplasm as meristem culture. The slow-growth tissue culture will be kept in precision incubators. In addition to in vitro storage a field genebank will be established at the OSU experimental farms for clonally propagated germplasm and OPGC greenhouse. Duplicate/backup collection will be established in network partner sites. In addition, OPGC has a 2.74 x 3.05 m vernalization room operating at around 8°C available for storing plant propagules.

Selection of Targeted Genera

During in the last seven years HOCGC developed a series of lists of recommended priority genera. The OPGC adopted the current list in its work plan. A summary of the HOCGC 1995, 1999 and 2001 lists consisting of 64 distinct genera is given in Table 3. At species level the number of taxa becomes enormous. For example, the 2001 priority genera list of the HOCGC summed up to some 6,692 taxa based on Hortus Third (1976). The ability to prioritize the species for conservation and to be selective on what genetic materials to collect and preserve become critical. The lack of stable taxonomic classifications in most ornamental plants is a challenge that both ornamental plant germplasm curators and plant breeders are experiencing. Survey and consultations with scientists and the industry are on-going to rank the HOCGC 30 priority genera so that the OPGC can concentrate its effort on the top genera.

Management of the Genebank

The management of OPGC's genebank is divided into two main sections. Firstly, the acquisition and conservation section with activities which encompass acquisition, post-entry quarantine, multiplication, characterization, identification of duplicates, accessioning, seed processing, viability testing, packaging, storage, further characterization and evaluation. Secondly, the documentation and distribution section is responsible for monitoring the flow if an accession into and out of the conservation system, and the status of utilization and distribution. The OPGC uses the USDA Germplasm Resources Information Network (GRIN) database management system (http://www.ars-grin.gov/npgs/) for managing its germplasm passport, characterization, evaluation, taxonomy, seed inventory and distribution data. The section also ensures that the collections are distributed widely for research purposes and accordingly to the USDA policies and procedures and to fulfill the quarantine requirements of recipient countries.

Status of the OPGC Collection

Most of the herbaceous ornamental plant accessions in NPGS have been transferred to OPGC. The current OPGC collection in the GRIN database consists of 966 accessions in 62 genera (Table 4). Many of them have low seed numbers and have to be regenerated for both base and active collection

before they can be made available for distribution. There are presently no characterization and evaluation data.

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Table 1: The number of accessions maintained at the NPGS sites in 2002.

Site	Accessions	Countries	Genera	Species
Barley Genetic Stocks Center (GSHO)	3,044	3	1	1
Clover collection (CLO)	246	30	1	118
Cotton Collection (COT)	9,308	124	1	41
Desert Legume Program (DLEG)	2,585	56	198	1279
Maize Genetic Stock Center (GSZE)	4,710	2	1	1
National Arboretum (NA)	1,909	51	257	861
National Arctic Plant Genetic Resources Unit (PALM)	493	31	50	145
National Arid Land Plant Genetic Resources Unit (PARL)	961	32	12	124
National Center for Genetic Resources Preservation (NSSL)	23,299	106	198	493
National Small Grains Collection (NSGC)	126,563	170	15	148
Natl. Germplasm Repository - Brownwood (BRW)	881	3	2	23
Natl. Germplasm Repository - Corvallis (COR)	11,687	92	56	757
Natl. Germplasm Repository - Davis (DAV)	5,105	79	19	202
Natl. Germplasm Repository - Geneva (GEN)	5,136	58	6	91
Natl. Germplasm Repository - Hilo (HILO)	675	41	22	76
Natl. Germplasm Repository - Mayaguez (MAY)	560	40	137	229
Natl. Germplasm Repository - Miami (MIA)	4,606	90	213	527
Natl. Germplasm Repository - Riverside (RIV)	1,167	30	38	152
North Central Regional PI Station (NC7)	47,032	177	319	1767
Northeast Regional PI Station (NE9)	11,730	126	32	196
Ornamental Plant Germplasm Center (OPGC)	967	58	62	287
Pea Genetic Stock Collection (GSPI)	501	3	1	2
Plant Germplasm Quarantine Office (PGQO)	4,827	59	19	76
Potato Germplasm Introduction Station (NR6)	5,503	38	1	168
Southern Regional PI Station (S9)	82,579	184	246	1433
Soybean Collection (SOY)	20,415	91	1	16
Tobacco Collection (TOB)	2,106	67	1	65
Tomato Genetic Stock Center (GSLY)	3,287	18	2	22
Western Regional PI Station (W6)	69,946	162	368	2423
Wheat Genetic Stocks Center (GSTR)	334	1	1	1
	========			
Total	452,162	N.A.		

Table 2: The current US National Plant Germplasm System's Crop Germplasm Committees (CGCs). (Refer to http://www.ars-grin.gov/npgs/cgclist.html for details on each CGCs).

1. Alfalfa CGC
2. Apple CGC
3. Barley CGC
4. Carya CGC
5. Citrus CGC
6. Clover CGC
7. Cotton CGC
8. Crucifer CGC
9. Cucurbit CGC
10. Food Legume CGC
11. Forage & Turf Grass CGC
12. Grape CGC
13. Herbaceous Ornamental CGC
14. Juglans CGC
15. Leafy Vegetable CGC
16. Maize CGC
17. New Crops CGC
18. Oat CGC
19. Pea CGC
20. Peanut CGC
21. Peppers CGC
22. Phaseolus CGC
23. Potato CGC
24. Prunus CGC
25. Pyrus CGC
26. Rice CGC
27. Root & Bulb CGC
28. Small Fruits CGC
29. Sorghum CGC
30. Soybean CGC
31. Sugarbeet CGC
32. Sunflower CGC
33. Sugarcane CGC
34. Sweetpotato CGC
35. Tobacco CGC
36. Tomato CGC
37. Tropical Fruit & Nut CGC
38. Vigna CGC
39. Wheat CGC
40. Woody Landscape Plant CGC

Table 3: Development of the USDA Herbaceous Ornamental Crop Germplasm Committee (HOCGC) priority genera list of herbaceous ornamentals

Year	**No. of Genera**	**Genus**
1995	24	*Ageratum, Alstroemeria, Aster, Begonia, Caladium, Catharanthus, Chrysanthemum, Dianthus, Dieffenbachia, Euphorbia, Eustoma, Hemerocallis, Hippeastrum, Impatiens, Kalanchoe, Liatris, Lilium, Lobelia, Pelargonium, Petunia, Spathiphyllum, Verbena, Zantedeschia and Zinnia*
1999	48	*Tagetes* (7), *Antirrhimum* (6), *Catharanthus* (6), *Chrysanthemum* (6), *Euphorbia* (6), *Impatiens* (6), *Iris* (6), *Pelargonium* (6), *Petunia* (6), *Verbena* (6), *Begonia* (5), *Dianthus* (5), *Salvia* (5), *Viola* (5), *Cyclamen* (4), *Geranium* (4), *Lilium* (4), *Penstemon* (4), *Aster* (3), *Crocus* (3), *Delphinium* (3), *Eustoma* (3), *Freesia* (3), *Gloxinia* (3), *Gypsophila* (3), *Hemerocallis* (3), *Lobelia* (3), *Orchidaceae* (3), *Saintpaulia* (3), *Alstroemeria* (2), *Campanula* (2), *Echinacea* (2), *Gazania* (2), *Gentiana* (2), *Heuchera* (2), *Hosta* (2), *Lantana* (2), *Liatris* (2), *Osteospermum* (2), *Paeonia* (2), *Papaver* (2), *Phlox* (2), *Primula* (2), *Rudbeckia* (2), *Senecio* (2), *Solidago* (2), *Veronica* (2) and *Vinca* (2) Note: The number in the brackets indicates the number of committee members selected the genus.
2001	30	*Algaonema* (50), *Alstroemeria* (60), *Anthurium* (600), *Aquilegia* (70), *Aster* (250-500), *Baptisia* (30-35), *Begonia* (1,000), *Campanula* (300), *Chrysanthemum* (100-200), *Dianthus* (300), *Dieffenbachia* (30), *Euphorbia*/Poinsettia (10), *Geranium* (300), *Hemerocallis* (15), *Impatiens* (500), *Iris* (200), *Lilium* (80-90), *Narcissus* (26), *Pelargonium* (280), *Petunia* (30), *Phalaenopsis* (55), *Philodendron* (200), *Phlox* (60), *Rudbeckia* (25), *Salvia* (750), *Spathiphyllum* (35), *Tagetes* (30), *Verbena* (200), *Veronica* (250) and *Viola* (500) Note: The number in the brackets indicates the number of species of the genus based on Hortus Third (1976) and the total number of taxa in the 30 genera is 6.692 taxa.
Total		**64** distinct genera from the three lists

Table 4: Number of herbaceous ornamental plant accessions in the OPGC collection (Acc. – Number of accessions)

Genus	**Acc.**	**Genus**	**Acc.**	**Genus**	**Acc.**
Adiantum	1	*Consolida*	6	*Penstemon*	56
Alstroemeria	1	*Convallaria*	1	*Petrorhagia*	1
Antirrhinum	88	*Coreopsis*	1	*Phlox*	2
Aquilegia	4	*Delphinium*	31	*Portulaca*	4
Argyranthemum	3	*Dianthus*	102	*Portulacaria*	2
Arum	1	*Echinops*	1	*Primula*	1
Aruncus	3	*Engelmannia*	1	*Pseudolysimachion*	4
Asclepias	20	*Filipendula*	1	*Rudbeckia*	2
Astilbe	6	*Geranium*	4	*Sanguisorba*	1
Astilboides	1	*Glandularia*	2	*Stokesia*	38
Begonia	3	*Gypsophila*	29	*Tagetes*	114
Bredia	1	*Impatiens*	1	*Trollius*	1
Campanula	34	*Iris*	36	*Turnera*	1
Canna	1	*Junellia*	1	*Veratrum*	1
Cardiocrinum	6	*Leonotis*	1	*Verbena*	17
Caulophyllum	1	*Leucanthemum*	90	*Veronica*	1
Chelidonium	1	*Liatris*	7	*Veronicastrum*	1
Chrysanthemum	9	*Ligularia*	6	*Viola*	15
Clematis	4	*Lilium*	35	*Xylanthemum*	2
Cleome	38	*Osteospermum*	43	*Zinnia*	74
Clintonia	1	*Pavonia*	2	**Total**	**966**