Crop Germplasm Committee Chairs Webinar

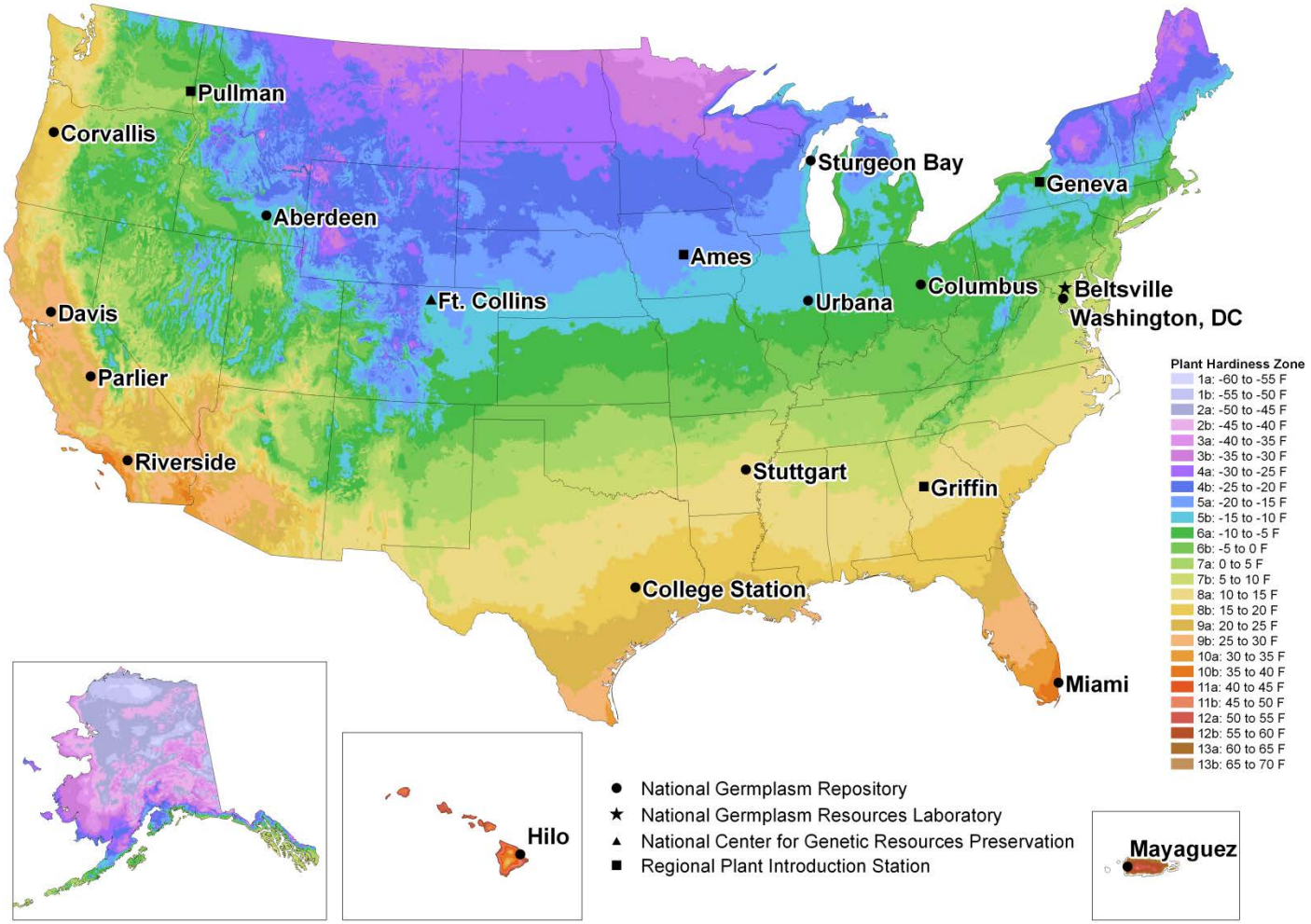
December 1, 2016

1:30 PM Eastern

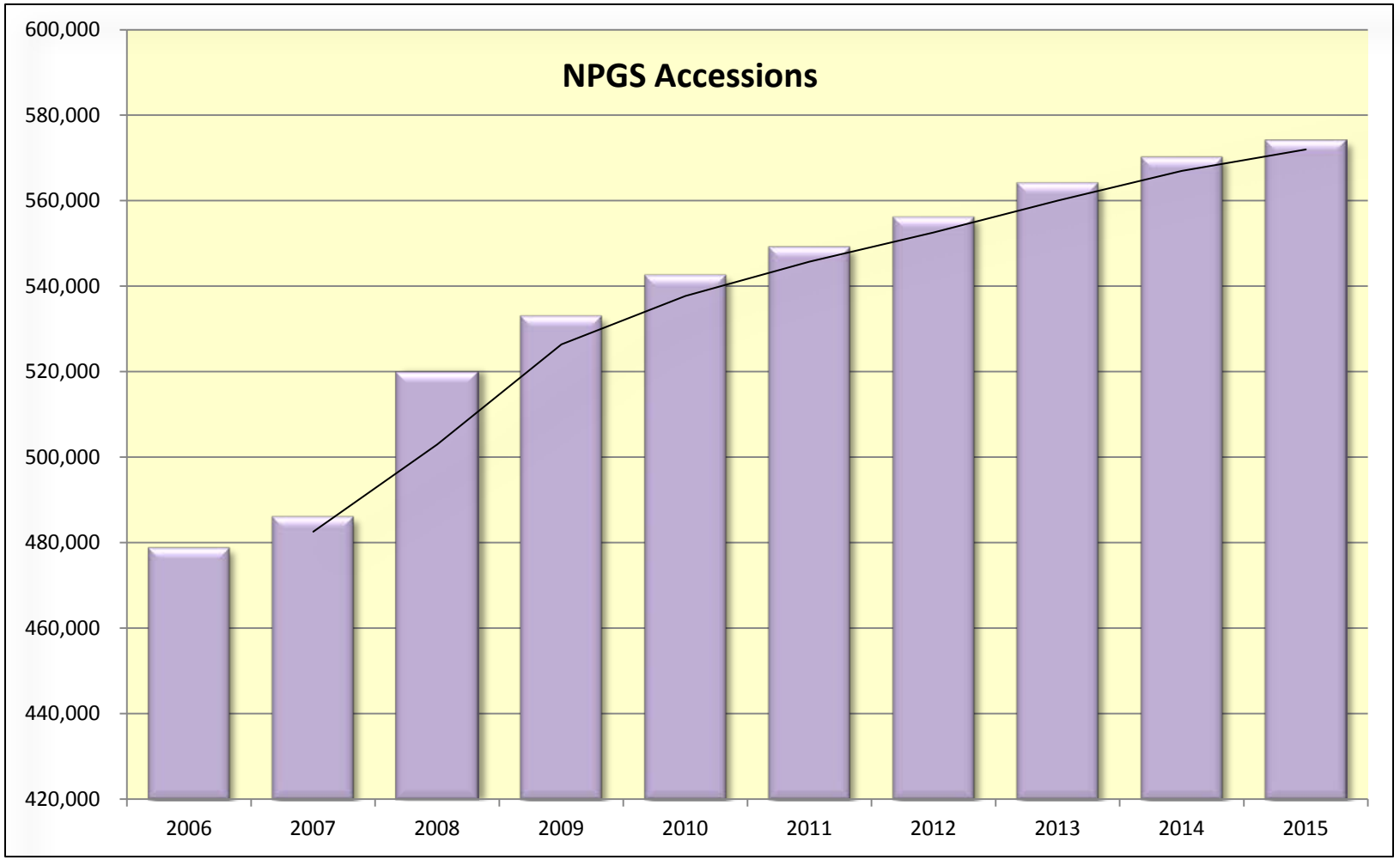
The National Plant Germplasm System: 2016 Status, Prospects, and Challenges

Peter Bretting
USDA/ARS Office of National Programs
Peter.bretting@ars.usda.gov
1.301.504.5541

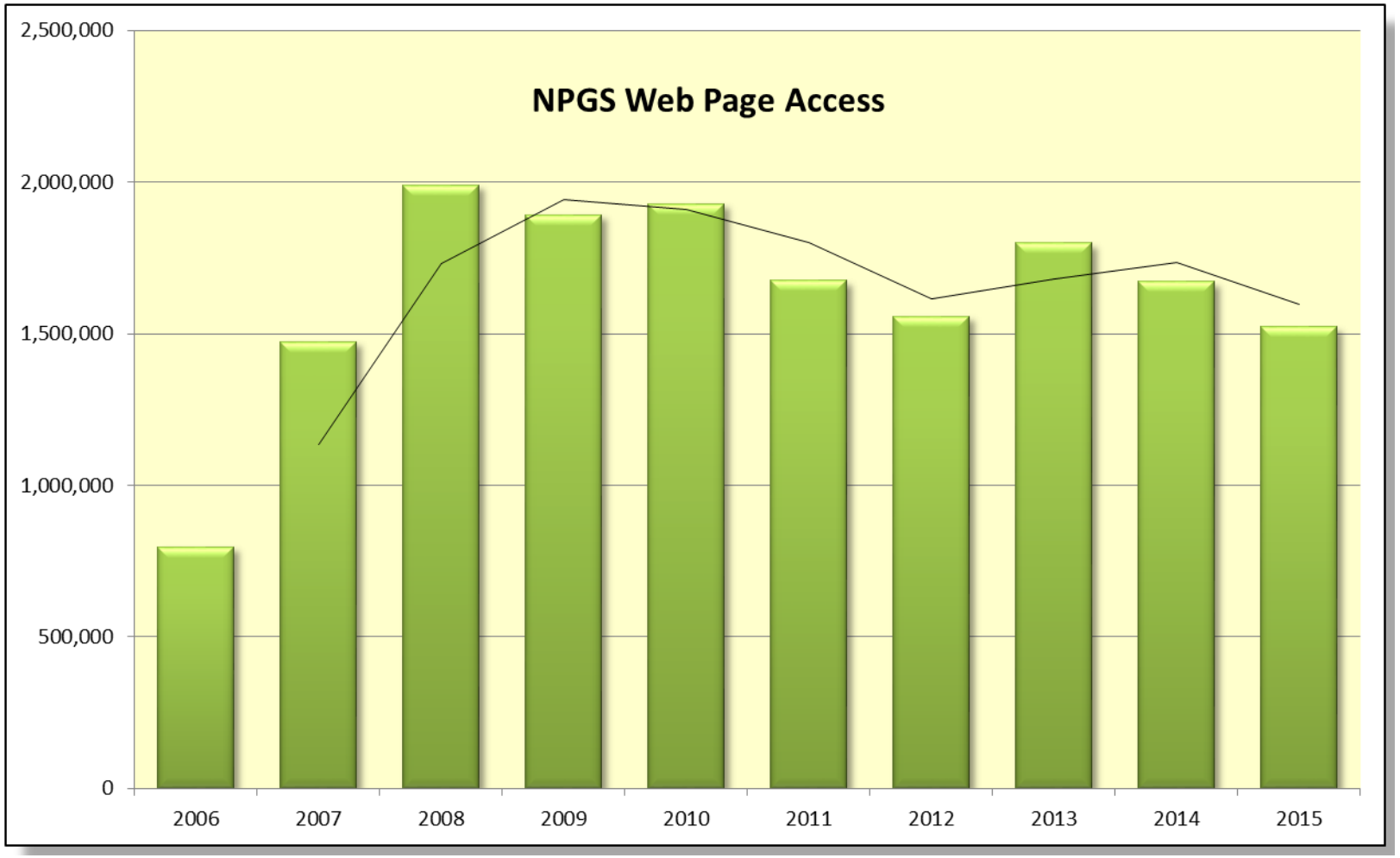
USDA National Plant Germplasm System (NPGS)



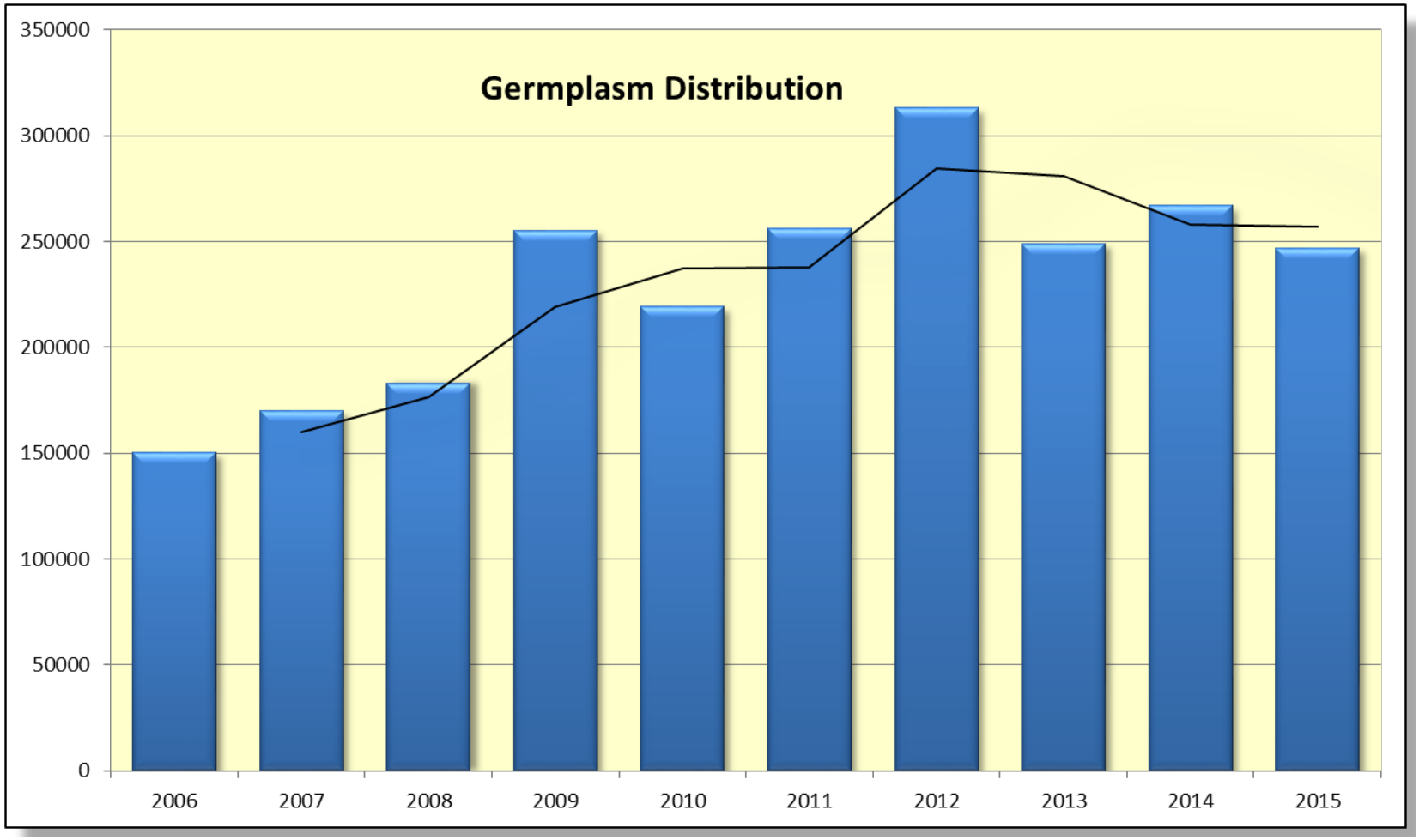
Number of NPGS Accessions 2006-2015



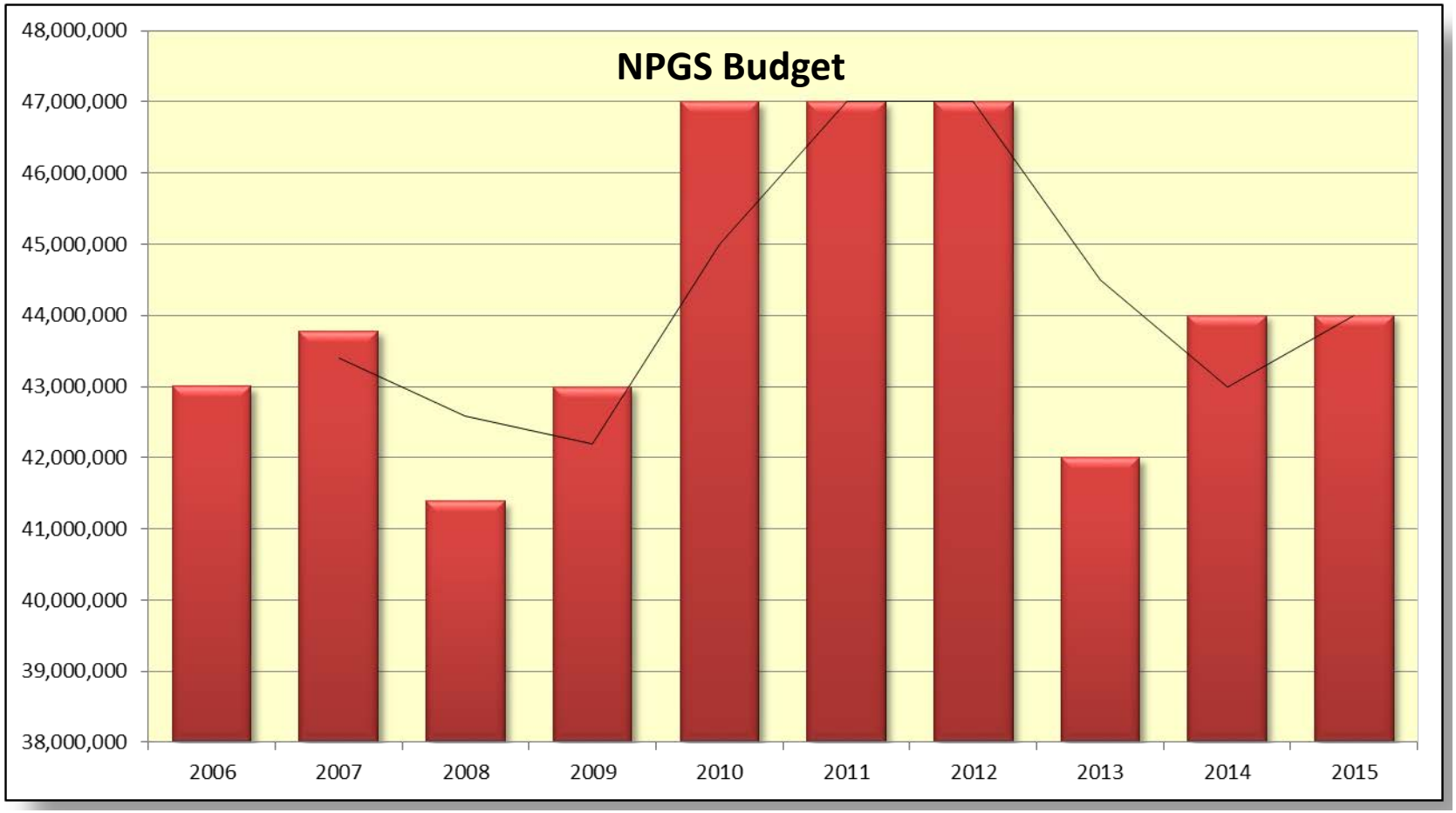
DEMAND FOR NPGS INFORMATION 2006-2015



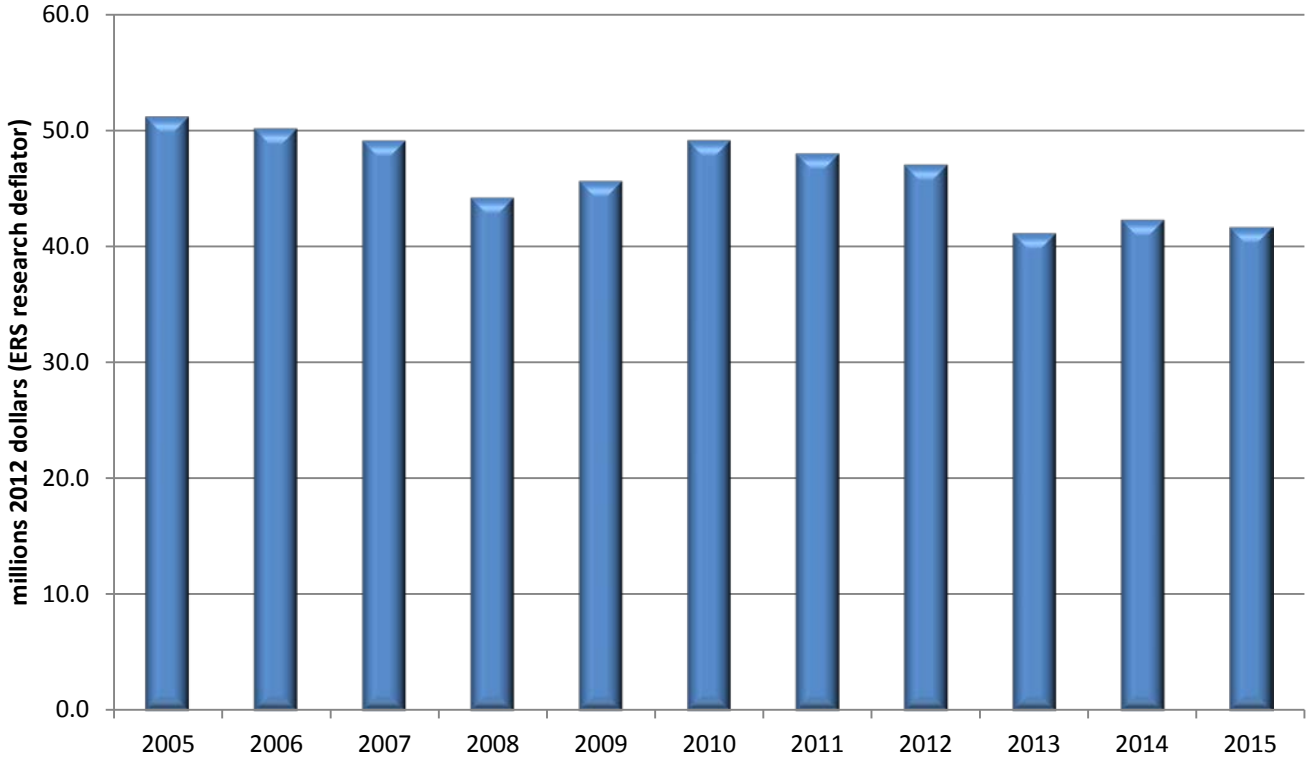
DEMAND FOR NPGS GERMPLASM 2006-2015



ARS National Plant Germplasm System budget 2006-2015



Real ARS National Plant Germplasm System Budget, 2005-2015, converted to 2012 dollars with ERS research deflator



Note: Deflator for 2015 is preliminary

Some key challenges that stretch the NPGS's resources

- **Managing and expanding the NPGS operational capacity and infrastructure to meet the increased demand for germplasm and associated information**
- **Recent and upcoming NPGS personnel retirements**
- **Fulfilling the demand for additional germplasm characterizations/evaluations**
- **Acquiring and conserving germplasm of crop wild relatives**
- **BMPs and procedures for managing accessions (and breeding stocks) with GE traits and the occurrence of adventitious presence (AP)**

A key priority: Crop Vulnerability Statements (CVS)

Assessing crop genetic vulnerability and setting NPGS priorities accordingly.

- **Template for constructing crop vulnerability statements**
- **Some CGC have published, or plan to publish, their CVS—e.g., Volk et al. 2014 The vulnerability of US apple (Malus) genetic resources. Genet. Resour. Crop Evol.**
- **But, CVS need not be that formal; Web-style content is fine.**
- **More important, update the CVS frequently; perhaps devote the beginning of CGC meetings to briefly reviewing and updating the CVS.**
- **The National Genetic Resources Advisory Council (NGRAC) will ask CGCs with outdated CVS to provide information they need for crop vulnerability assessments.**

Genetic Resource Management Priorities

- Acquisition
- Maintenance
- Regeneration
- Documentation and Data Management
- Distribution
- Characterization
- Evaluation
- Enhancement
- Research in support of the preceding priorities

Personnel Changes

- **Farewell and best wishes to Barbara Reed (NCGR-Corvallis), RC Johnson (WRPIS-Pullman) and Dan Barney (NCRPIS-Ames) for their retirements.**
- **Congratulations and best wishes to Richard Olsen, formerly lead scientist for the USNA-Washington, DC genebank project, on becoming the new Director, USNA.**
- **Best wishes to Brian Irish who moved from TARS-Mayagüez to WRPIS-Pullman/Prosser to be the new alfalfa and clover curator.**
- **Welcome and best wishes to Shyam Tallury, new peanut curator at SRPIS-Griffin; Claire Heinitz, new curator at NALPGR–Parlier; and Mary Lou Polek, the new RL for the NCGR-Riverside.**

Background for FAO International Treaty (IT) on Plant Genetic Resources for Food and Agriculture

The IT, a legally-binding Treaty under the UN Food and Agriculture Organization (FAO), has these objectives:

- **the conservation and sustainable use of PGRFA (Plant Genetic Resources for Food and Agriculture) and**
- **the fair and equitable sharing of the benefits arising out of their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security.**

Background for the IT

- **130+ nations are Parties. The U. S. (Pres. G. W. Bush) signed in 2002; the U. S. Senate passed a Resolution of Ratification (advice and consent) on 28 September 2016.**
- **The U. S. will become an IT Party 90 days after deposit of its instrument of ratification at FAO in Rome—sometime during the next few months.**

Background for the IT

Nations have sovereign rights over "their" PGRFA and in exercise of those rights Parties agree to:

- **Establish a MultiLateral System (MLS) for facilitated access to and benefit-sharing of certain PGRFA for conservation and utilization for research, breeding, and training. These improve food security.**
- **Establish provisions for PGRFA in International Agricultural Research Centers (IARCs, e.g., CIMMYT, IRRI).**

Background for the IT

The IT covers all PGRFA. But the MLS includes:

- **PGRFA of 64 food and feed crops key to food security; more crops may be included in the future. See http://www.fao.org/3/a-i0510e.pdf for the list in Annex 1: includes maize, sorghum—not soybean.**
- **Under the management and control of national governments (e.g., US National Plant Germplasm System), in the public domain; or held by IARCs; or**
- **Made available voluntarily by private entities.**

Background for the IT

Germplasm access and exchange under the MLS are via the SMTA, which includes conditions for end use (excludes non-food and non-feed), conservation, and benefit-sharing upon commercialization. See http://www.fao.org/3/a-bc083e.pdf for the SMTA text.

Effects of the US becoming an IT Party

The NPGS will need to undertake certain tasks, including reporting, information-sharing and curation, but it is already fulfilling nearly all of those. No new legislation is needed. Non-governmental US public and private-sector PGRFA owners and users would incur no obligations.

Effects of the US becoming an IT Party

As a Party, the US government can more effectively represent US germplasm users at the IT's Governing Body, advance US priorities and interests, and strive to improve some aspects of the IT and the SMTA.

Effects of the US becoming an IT Party

- **US PGRFA users, both public and private-sector, will have guaranteed access to PGRFA from other Parties and IARCs.**
- **Access will be granted according to the standardized terms of the SMTA; no additional negotiations needed.**

Effects of the US becoming an IT Party

- **US government will provide access to Annex 1 NPGS PGRFA to non-US users accompanied by the SMTA.**
- **Terms of access to NPGS PGRFA acquired without an SMTA would not change for US users.**
- **Does not affect use of PGRFA acquired pre-IT, nor domestic US PGRFA exchange.**

National Laboratory for Genetic Resources Preservation

United States Department of Agriculture

Agricultural Research Service

Stephanie Greene
stephanie.greene@ars.usda.gov
970-492-7531

Plant and Animal Genetic Resources Preservation Unit

Securing and managing safety duplication collections of the National Plant Germplasm System and other agencies through diligent stewardship, research and communication

(Harvey Blackburn, Acting RL; Stephanie Greene, Seed Curator; Maria Jenderek, Clonal Curator)

Plant Germplasm Preservation Research Unit

Developing state-of-art tools to improve gene bank capacity and efficiency

(Christina Walters , RL; Gayle Volk, Research Plant Physiologist; Chris Richards, Research Geneticist)

Worlds largest collection of germplasm under one roof

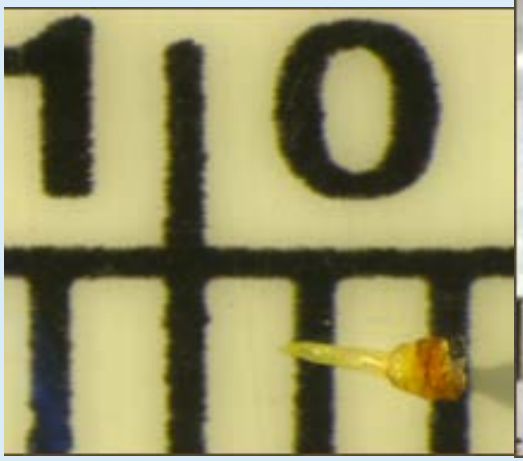
Seed Storage at NLGRP

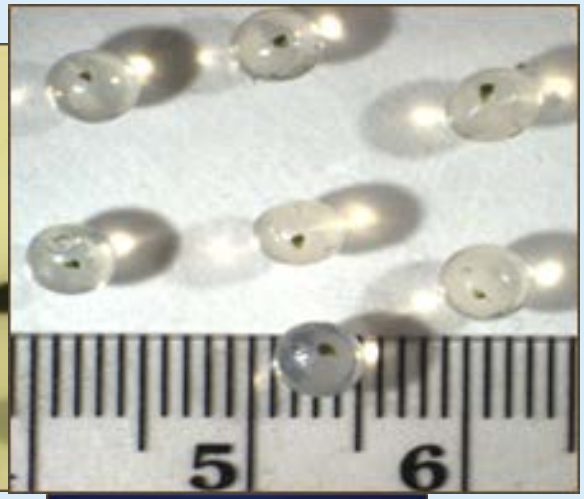
Cryogenic Storage (-196 ºC)

Conventional Cold Storage (-18ºC)

Cryopreservation of clonal collections

Dormant Buds

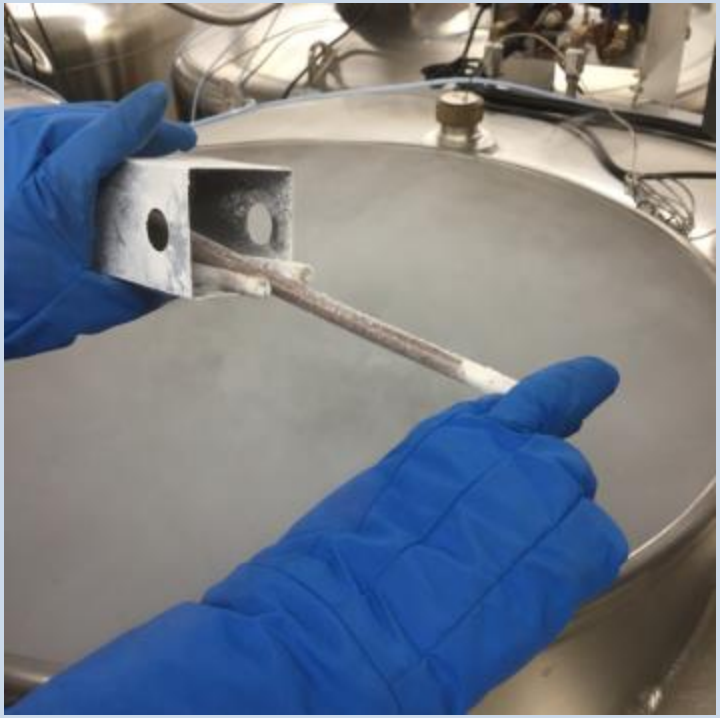




Shoot meristems

Our main mission: secure the NPGS collection

86% - seed collection
15% - clonal collection
3% - NPGS accessions unique to NLGRP



Secure storage for 79 other agencies

- 7527 PVP voucher samples
- 2642 *Journal of Plant Registration* voucher samples
- 360,000 “black-box” accessions – i.e. CGIAR, Seed Savers Exchange, botanical gardens, USFS, Indian Tribes (*Fraxinus*), historic special collections (i.e. McClintock’s maize lines)

2016 Activities

- Staffing: Large number of recent retirements. Currently working to fill five vacancies.
- Received and processed 18,000 seed packets. 35% NPGS, 28% non-NPGS, 4% PVP/JPR, 33% Svalbard; conducted 7411 viability tests
- Shipped 19,000 samples to Svalbard Seed Vault, 20% of U.S. collection is now backed up
- Processed 743 clonal samples for long term cryopreservation

- Since 2014, monitor testing has focused on short lived species that have not been tested in 10-20 years. Testing indicates that short lived species (i.e. lettuce, onion) need to be replenished. Curators will be notified
- Continued our partnership with the BLM Seeds of Success Program, providing long term storage for native species
- Conducted 51 tours with a total of 719 participants; conducted classes for Colorado Native Plant Society, BLM SOS collectors; hosted the Joint NPGS meeting in June

Summary of security backup

Interested in knowing the backup status of your crops? Contact me for details

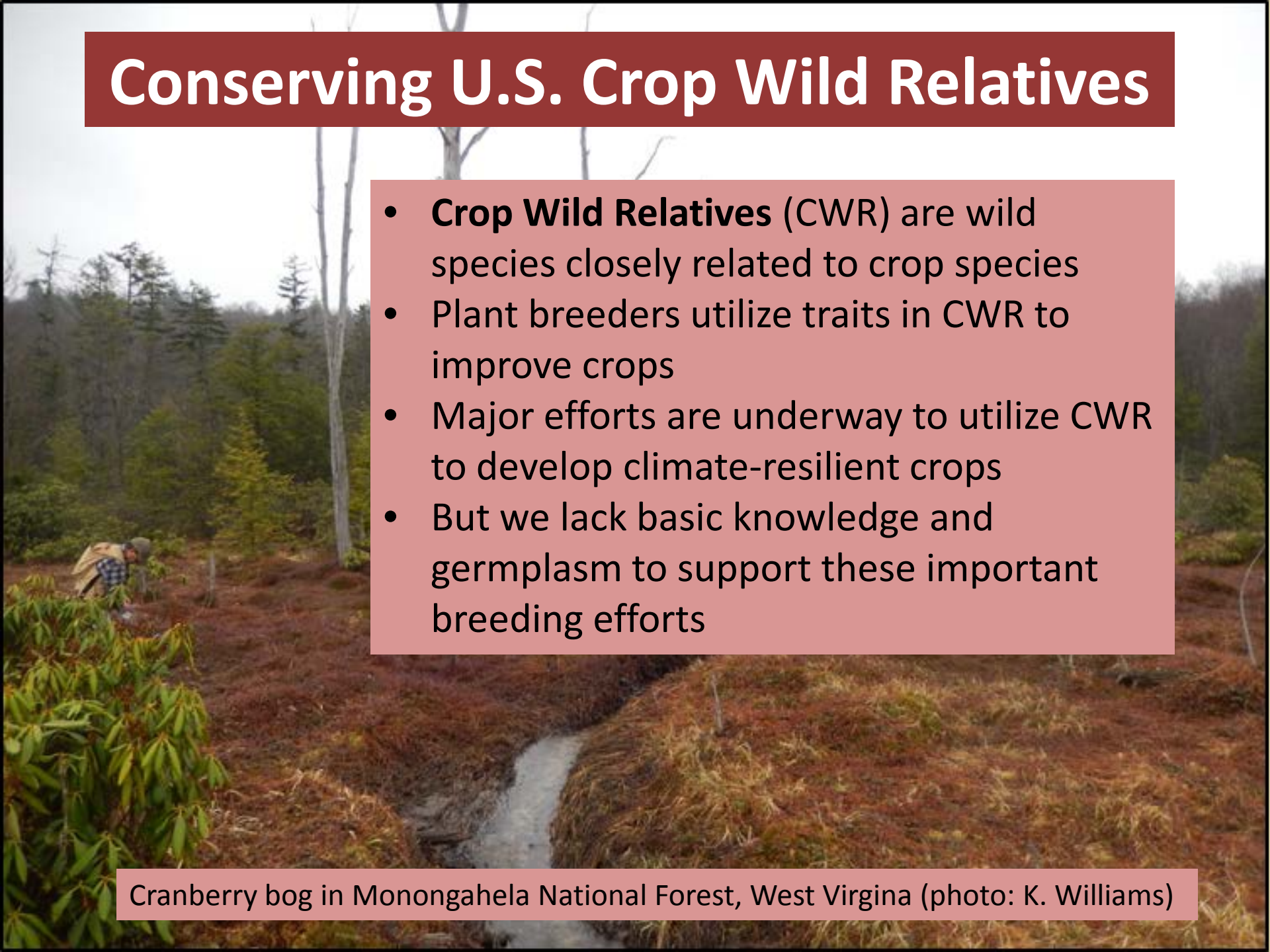
- Cryopreservation of clonal crops is limited due to resource constraints and need to develop protocols. Exploring seed preservation for wild and landrace germplasm

- Most seed crops are adequately backed up. What is not backed up are samples queued for regeneration or having small seed quantities

- More emphasis needs to be placed on replenishing back up samples that have low viability. This is especially relevant for short lived species that have been stored at Fort Collins for the last 20-30 years

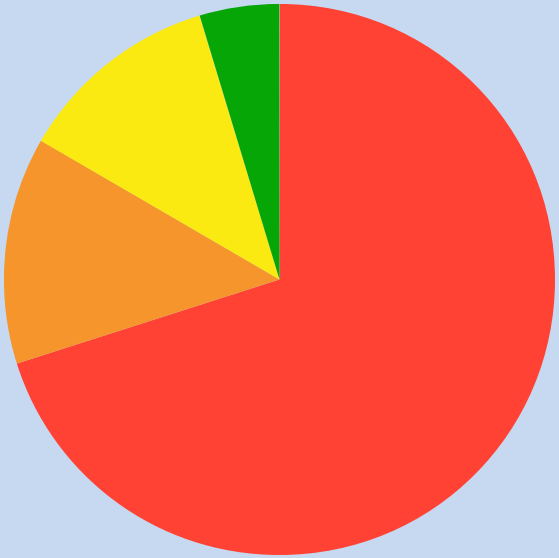
Conserving U.S. Crop Wild Relatives

- **Crop Wild Relatives** (CWR) are wild species closely related to crop species
- Plant breeders utilize traits in CWR to improve crops
- Major efforts are underway to utilize CWR to develop climate-resilient crops
- But we lack basic knowledge and germplasm to support these important breeding efforts



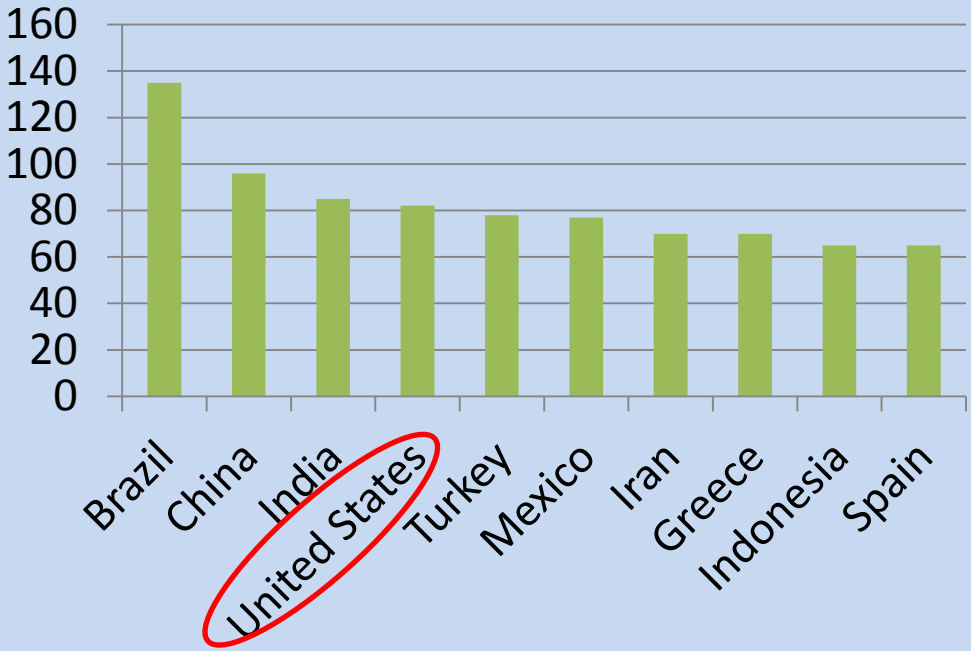
Cranberry bog in Monongahela National Forest, West Virgina (photo: K. Williams)

US ranked 4th for CWR needing to be collected



Globally, *ex situ* gaps were examined for 1,100 CWR species of 81 crops. 70% were high priority to collect

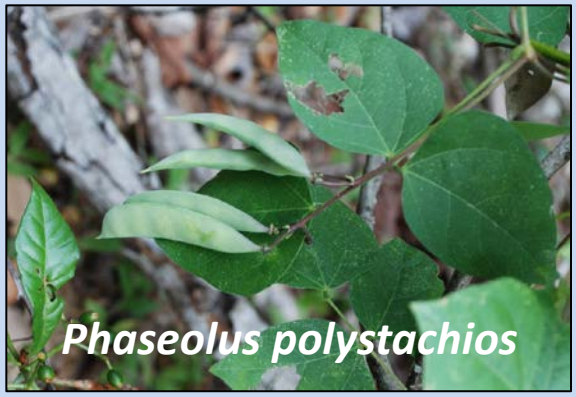
Crop Wild Relatives and Climate Change (2013) Online resource. Accessed on 10-04-2015. www.cwrdiversity.org



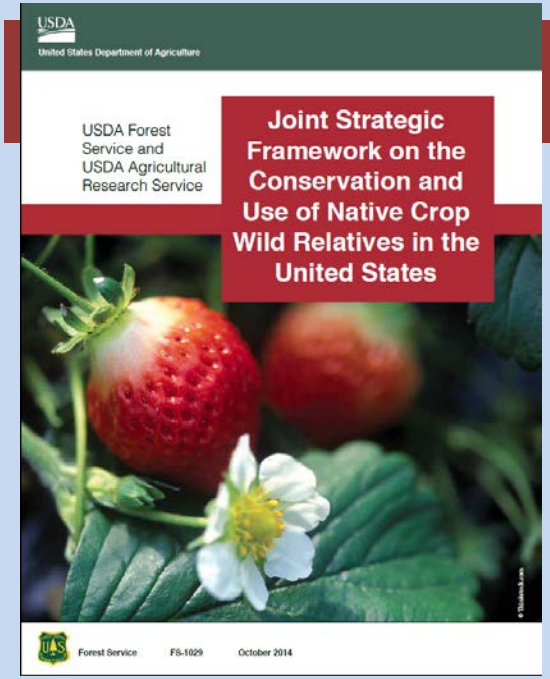
But what exactly grows in our backyard?

- ARS developed an inventory of 4,600 taxa, 285 identified as high priority to collect
- Important CWR: sunflower, stone fruits (cherry, plums), berries, (strawberries, gooseberry, currants, raspberry, blackberry, blueberry, cranberry), grape, lupines
- CWR with limited representation in U.S. gene banks: cotton, lettuce, stone fruits, berries, sugarcane, *Tripsacum* (maize) and *Zizania* (wild rice)

Khoury et al. (2013). An Inventory of Crop Wild Relatives of the United States. Crop Sci. 53(4): 1496.



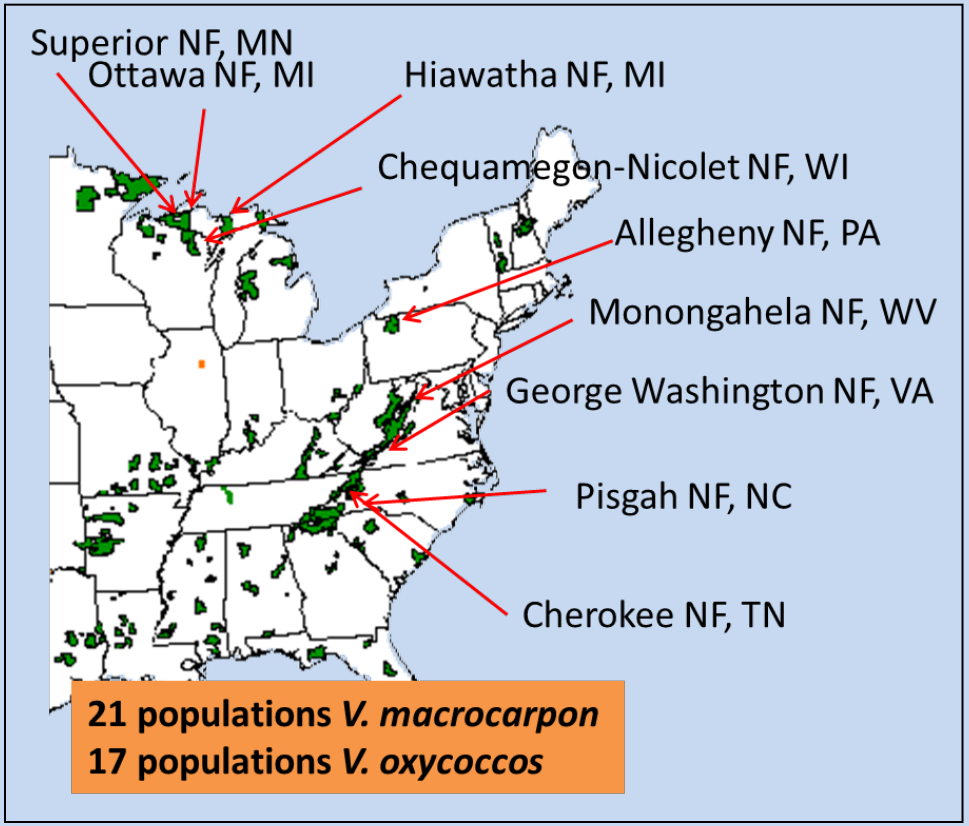
Forged interagency partnerships



- FS\ARS MOU on conservation of native plants – 2011
- Joint Strategic Framework– 2014
- BLM Seeds of Success program

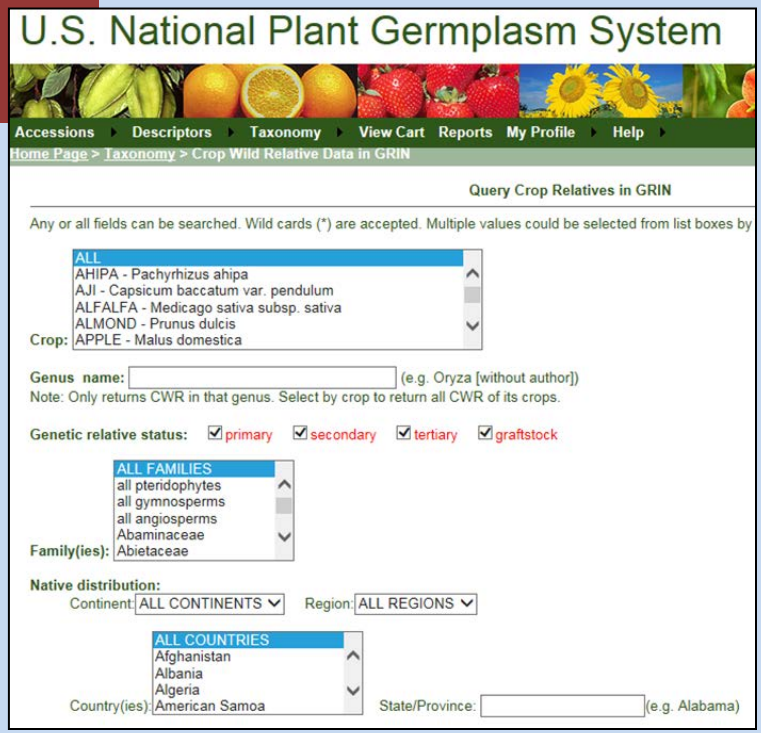
Case study (ARS/USFS): Cranberry

- Plant characteristics, environment (biotic and abiotic), herbarium vouchers, population size, health, accessibility, potential threats
- Evaluation of genetic diversity (leaf tissue analyzed using 9 microsatellite markers) at ARS\Univ. of Wisconsin (Juan Zalapa)
- Goal- designate *In Situ* Reserves



Developed knowledge base and collected CWR

NPGS developed a globally comprehensive CWR database publically available on GRIN Global

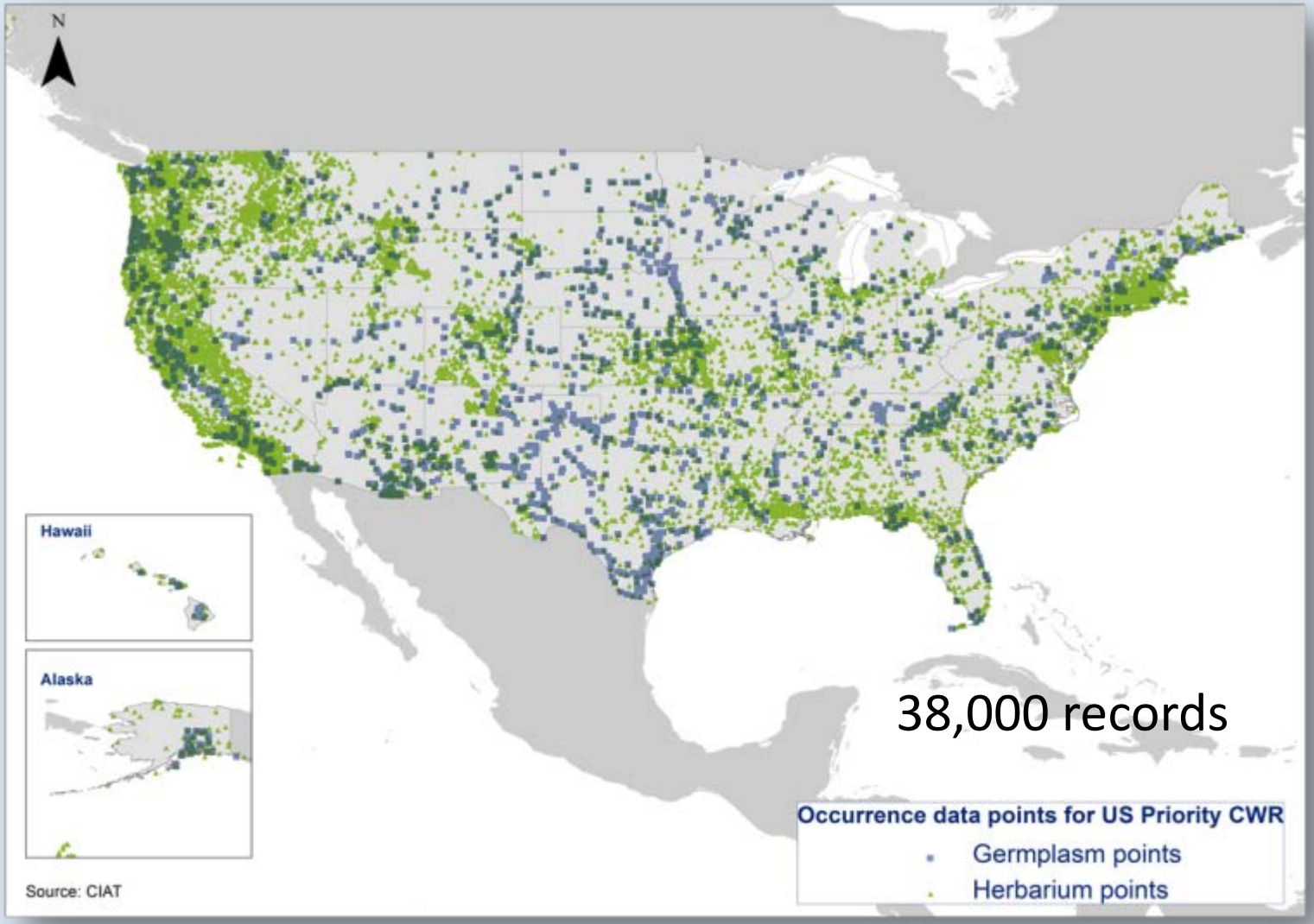


Wild potato, Arizona

USDA-ARS Plant Exploration program filled gaps in the NPGS collection with recent explorations for CWR of potato, quinoa, sunflower, bean, sweet potato, and squash

US CWR gap analysis

Dr. Colin Khoury
Chrystian Sosa



Info on methods: Ramírez-Villegas et al (2010) A Gap Analysis Methodology for Collecting Crop Genepools: A Case Study with *Phaseolus* Beans. *PLoS ONE* 5(10): e13497. doi:10.1371/journal.pone.0013497. http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0013497

Expected Outcomes from Gap Analysis

- Distribution models of CWR
- *Ex situ* acquisition needs identified and prioritized
- Hot spots of diversity identified
- Overlap of CWR distributions with protected areas
- Data made publically available by integrating with databases such as NatureServe and NRCS Plants Database
- Information provided directly to land managers and interested organizations

Spreading the word

- CSSA CWR Symposium (Nov. 2015)
- *Crop Science* CWR Special Issue (2017)
- *Valuable plants of North America: Crop wild relatives and wild utilized species* (Eds. S. Greene, K. Williams, C. Khoury, L. Marek, and M. Kantar), Springer Pub. (2017)
- National Genetic Resource Advisory Council (C. Khoury, 2016)
- Plant Conservation Alliance (K.Williams, Feb, 2016)
- CWR workshop, USFS Forest Tree Genetic Resource conference (C. Khoury, May 2016)
- USFS Regional Botanist Meeting (K. Williams, C. Khoury, Sept, 2016)

Crop wild relatives of the United States White Paper:

"Conserving wild diversity for food security: Enhancing the resilience of agriculture by securing U.S. native plant genetic resources"

Provides a road map and budget to support our goals:

- Comprehensive and easily accessed information on CWR species, their distributions, occurrences, and conservation status
- Broad diversity of CWR secured *in situ* and *ex situ*
- Germplasm of CWR readily available to plant breeders and scientists
- National strategy for long-term conservation of CWR of the U.S. established and activated, involving broad partnerships across federal and state agencies, tribal nations, NGOs, universities, and beyond

Thanks for your attention

Questions?

Plant Exchange Office
National Germplasm Resources Laboratory
Beltsville, Maryland

Karen A. Williams Karen.Williams@ars.usda.gov
John Wiersema John.Wiersema@ars.usda.gov




Plant Exchange Office Personnel

- John Wiersema, Botanist\GRIN Taxonomy
- Karen Williams, Botanist\Explorations & Exchanges
- Jennifer Friedman, Biological Science Technician\Import & Export of Germplasm

The NPGS Plant Exploration/Exchange Program

- fills gaps in the NPGS
- proposals accepted yearly by NGRL- PEO for explorations the next fiscal year
- proposals for 2017 being reviewed by NPS
- proposals for 2018 due July 21, 2017
- guidelines distributed to CGC Chairs
- supports both explorations and exchanges
- CGCs and curators must endorse proposals

2016 Plant Explorations\Exchanges

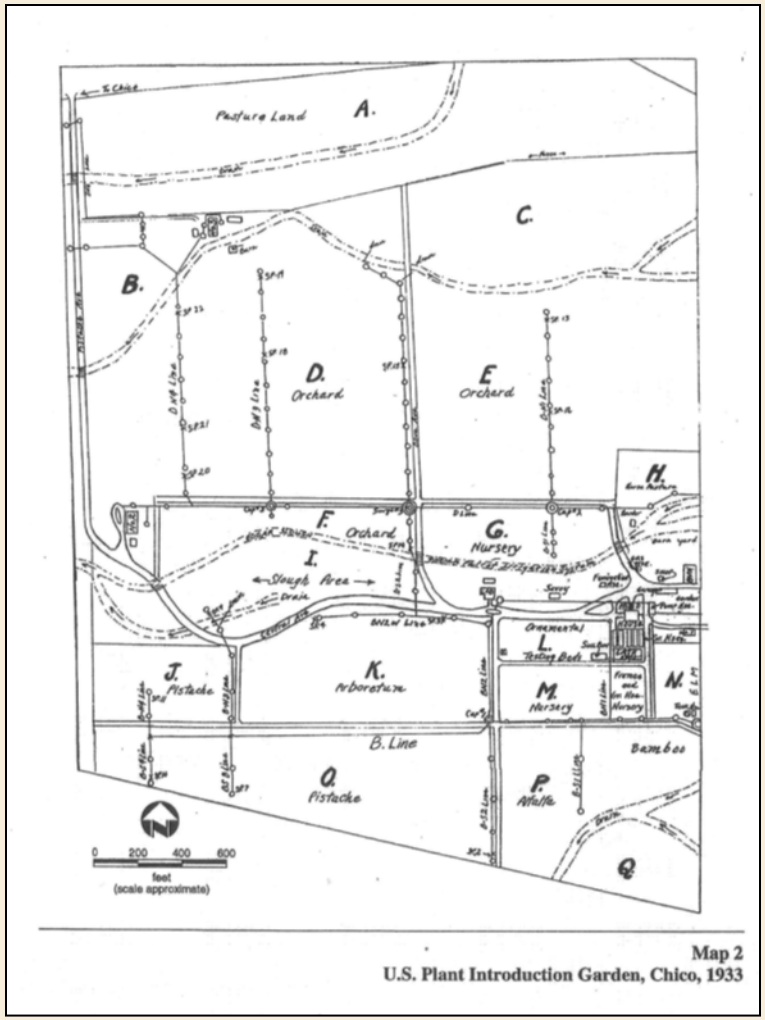
Small fruits	Vietnam
Carrot and onion (2 trips)	Spain
Ornamentals	Georgia
Wild sunflower	United States (AL, FL)
Ash *(Fraxinus quadrangulata)*	United States (OH, KY, IN, TN)
Kentucky coffeetree	United States (IL, IN, MI)
Herbaceous ornamentals	United States (TX)
Wild apple	United States (AR, LA, MI)
Hardy kiwifruit (exchange)	United States
Wild bean	United States (OH)
Wild potato	United States (AZ, NM)

2016 Explorations

Access and Benefit Sharing for International Explorations

- explorations abide by CBD Article 15
- prior informed consent (PIC) obtained from national authority
- PIC may be in the form of a letter, permit, MTA, etc.
- includes agreement on the sharing of benefits
- acceptable benefits are “in-kind” (training, equipment purchase, increase projects, etc.)
- PEO obtains PIC
- SMTA provides terms for some explorations

Identification of Historical Plant Introductions USDA Plant Introduction Garden, Chico, CA (Ned Garvey, collaborator)



Map 2
U.S. Plant Introduction Garden, Chico, 1933

- first USDA plant introduction garden (est. 1904)
- over 200 acres

USDA Plant Introduction Garden
Chico, CA

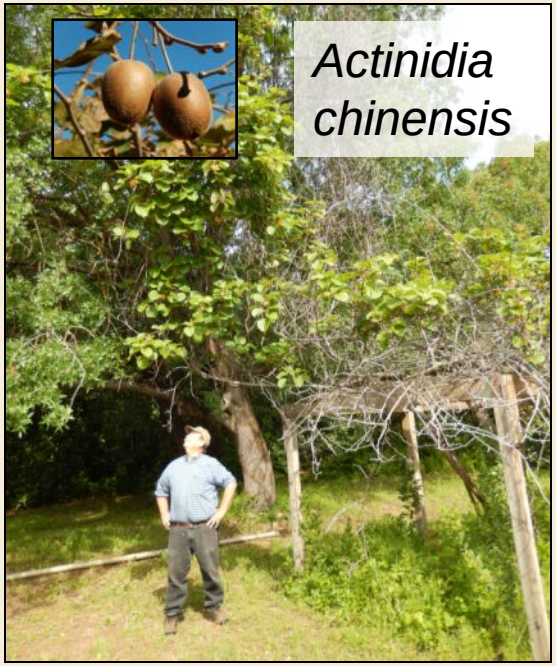
Google Earth view of station today

- transferred from ARS to USFS in 1974
- currently used by USFS as a seed orchard and research facility

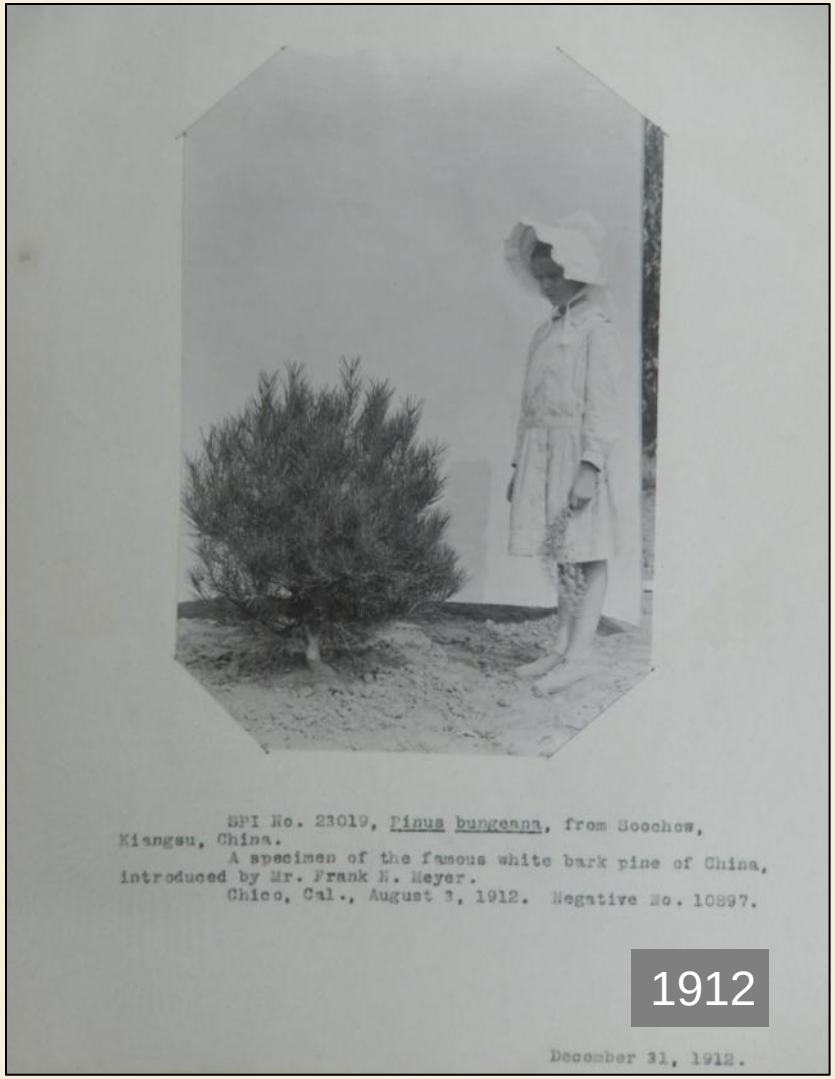
Seed orchard

Summary of PIs Documented

- 113 unique PIs identified and labeled
- most are not in the NPGS
- woody ornamentals and fruits (apple, citrus, feijoa, kiwi, pomegranate)
- germplasm of 15 PIs collected thus far
- many other specimens could not be documented

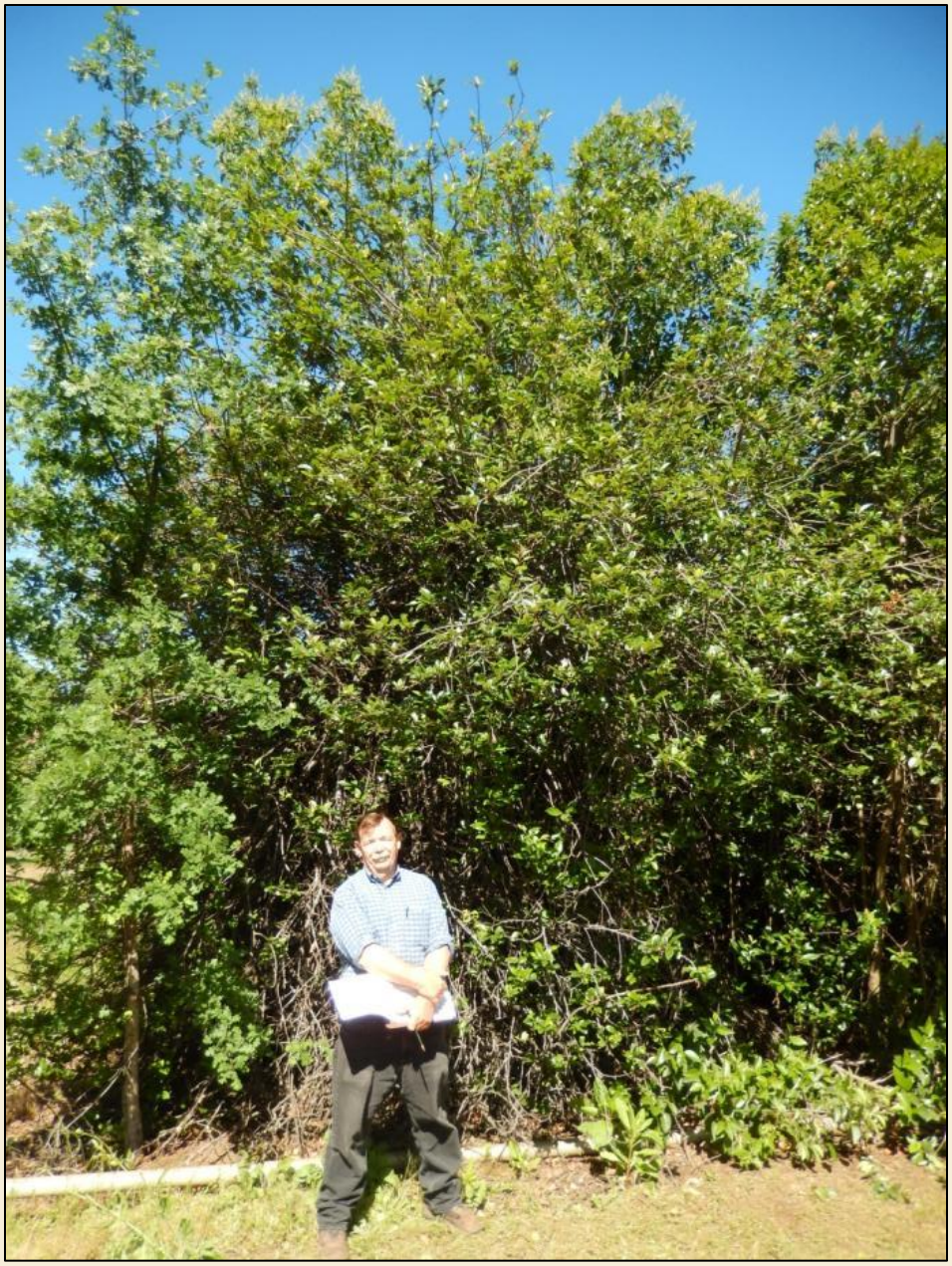


Pinus bungeana
PI 23019
Soochow, Jiangsu, China
Frank Meyer, 1908



1912

2015



Malus halliana
PI 38231
China
Frank Meyer, 1914

Asian persimmon (*Diospyros kaki*)

26 PIs from China, Japan and Korea, 1910 - 1964

U.S. National Plant Germplasm System

Query all GRIN Taxonomy for Plants:

Simple queries - species data, single criterion
Browse taxonomy
Advanced queries - species data, multiple criteria
Queries of family and generic data

Query specialized parts of GRIN Taxonomy for Plants:

Economic Plants

U.S. National Plant Germplasm System

Simple Query of GRIN TAXONOMY Species Data

Enter search criterion. Wild cards (*) are accepted: Search

You can search for any one of these identifiers:

- **Scientific name** (e.g. *Triticum aestivum* [without author]).
- **Common name** (e.g. wheat [no diacritics].
- **Genus name** (e.g. *Triticum*).
- **Family name** (e.g. Poaceae).
- **Species nomen number** (e.g. 40544).
- **Country in species native range** (e.g. Zaire).

Advanced Query of GRIN TAXONOMY Species Data

Any or all fields can be searched. Wild cards (*) are accepted. Multiple values could be selected from list boxes by using shift or control key.

Genus or species name: (e.g. *Arachis* or *Zea Mays* [without author])

Family(ies):
- ALL FAMILIES
- all pteridophytes
- all gymnosperms
- all angiosperms
- plant pathogens
- Abaminaceae

Common name: (e.g. maize [no diacritics])

Native distribution: Continent: ALL CONTINENTS Region: ALL REGIONS

Country(ies):
- ALL COUNTRIES
- Afghanistan
- Albania
- Algeria
- American Samoa

State/Province: (e.g. Alabama)

Non-native distribution: (entry as **Or** **And** criterion) (e.g. cultivated, naturalized, Africa, United States, Macaronesia)

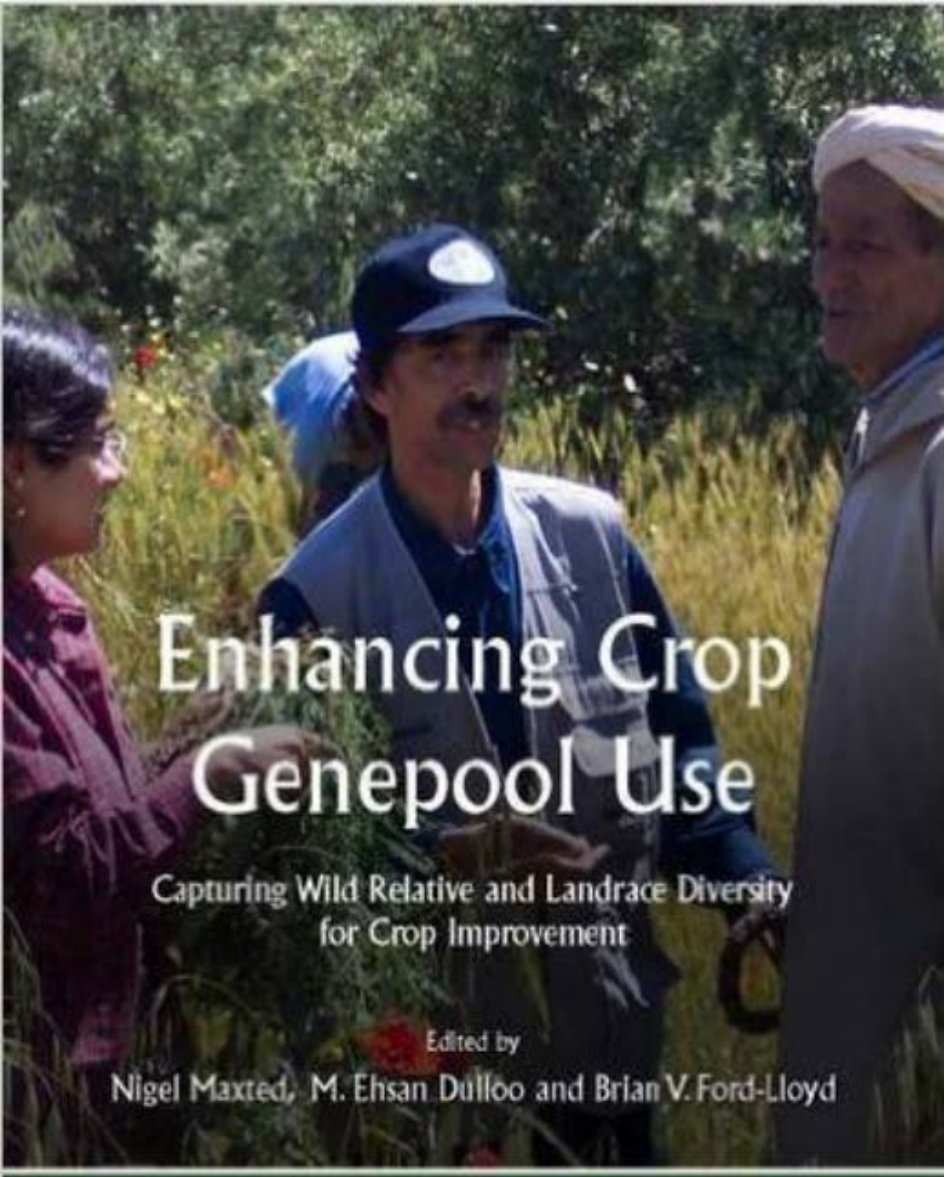
Restrict to only accepted names

Restrict to names with germplasm in GRIN

Search

GRIN-Taxonomy
Crop Wild Relative (CWR)
Inventory

1. PEO Project initiated in 2008 to assess CWR germplasm needs for NPGS
2. Identify CWR by “gene pool” status
3. Supporting data gleaned from multiple sources
4. Seek external review of treatment



42 The GRIN Taxonomy Crop Wild Relative Inventory

J.H. Wiersema[1]* and B. León[2]
[1]US Department of Agriculture, National Germplasm Resources Laboratory, Beltsville, Maryland, USA; [2]Plant Resources Center, University of Texas at Austin, Austin, Texas, USA

42.1 Introduction

The recognized link between cultivated crops and wild-related species is well established. The genetic diversity of the wild relatives of a crop provides the raw material for its genetic improvement to increase yield, provide disease or pest resistance, improve nutrition or processing quality of products, or reduce environmental effects from cultivation (Gepts, 2006). Faced with the ever-increasing threats of habitat loss or degradation and the uncertain future effects of climate change, the urgency to identify and conserve crop wild relatives (CWRs) for the benefit of current and future agricultural crop production and protection has never been greater. The strategy of the *ex situ* conservation of plant genetic resources is crucial to agricultural research and development (Bömer, 2006), and the National Plant Germplasm System (NPGS) of the US Department of Agriculture's Agricultural Research Service has been an important participant in this activity since its inception in the mid-1900s (Shands, 1995). The NPGS is charged with acquiring and conserving the genetic diversity of all crop plants important to US agriculture, and over 565,000 accessions of some 14,700 species are already being preserved *ex situ* in NPGS.

To assist with the preservation of CWRs, the Plant Exchange Office (PEO) of the NPGS's National Germplasm Resources Laboratory initiated in late 2008 a project to identify systematically the CWRs of major and minor US crops. The Germplasm Resources Information Network (GRIN: http://www.ars-grin.gov/npgs/) of the NPGS would then provide the means to link passport data on existing accessions with the accumulated taxonomic data on CWRs from this project. These data, taken together, would allow us to evaluate gaps in the current NPGS holdings of CWRs and set priorities for future germplasm conservation strategies.

Here, we provide a discussion of the concepts and terminology that underlie the CWR classification of this project. We also outline the procedures for compiling and evaluating this classification and the public accessibility of the resulting data.

42.2 Classifying Crop Wild Relatives

In order to identify and evaluate the relative importance of CWRs for various crops, it is necessary to establish a method of classifying the crop's relatives that prioritizes each species potential to donate genes for crop improvement.

*Corresponding author; e-mail: John.Wiersema@ARS.USDA.GOV

 Enhancing Crop Genepool Use: Capturing Wild Relative and Landrace Diversity for Crop Improvement (eds N. Maxted, M. Ehsan Dulloo and B.V. Ford-Lloyd)

Crop Genera (99) Treated (190 crops)

Cereal: *Avena*, *Cenchrus*, *Eleusine*, *Eragrostis*, *Hordeum*, *Oryza*, *Secale*, *Sorghum*, *Triticum*, *Zea*, *Zizania*

Culinary Herb: *Brassica*, *Carum*, *Cinnamomum*, *Humulus*, *Mentha*, *Piper*, *Sinapis*, *Vanilla*, *Zingiber*

Fiber: *Gossypium*, *Linum*

Forage: *Medicago*, *Trifolium*

Fruit/Nut: *Actinidia*, *Ananas*, *Annona*, *Artocarpus*, *Carica*, *Carya*, *Castanea*, *Citrullus*, *Citrus*, *Corylus*, *Diospyros*, *Eriobotrya*, *Fragaria*, *Garcinia*, *Juglans*, *Macadamia*, *Malus*, *Mangifera*, *Musa*, *Olea*, *Persea*, *Phoenix*, *Physalis*, *Pistacia*, *Prunus*, *Pyrus*, *Ribes*, *Rubus*, *Solanum*, *Theobroma*, *Vaccinium*, *Vitis*

Oilseed: *Brassica*, *Carthamus*, *Crambe*, *Helianthus*, *Olea*, *Simmondsia*

Pseudocereal: *Amaranthus*, *Chenopodium*

Pulse: *Arachis*, *Cajanus*, *Cicer*, *Glycine*, *Lens*, *Lupinus*

Vegetable: *Allium*, *Alocasia*, *Arracacia*, *Asparagus*, *Beta*, *Brassica*, *Cajanus*, *Canavalia*, *Capsicum*, *Cichorium*, *Colocasia*, *Cucumis*, *Cucurbita*, *Cynara*, *Daucus*, *Dioscorea*, *Eruca*, *Ipomoea*, *Lactuca*, *Pachyrhizus*, *Pastinaca*, *Phaseolus*, *Pisum*, *Raphanus*, *Rheum*, *Sechium*, *Solanum*, *Spinacia*, *Vicia*, *Vigna*

Other: *Beta*, *Camellia*, *Coffea*, *Manihot*, *Nicotiana*, *Saccharum*

Query Crop Relatives in GRIN

Any or all fields can be searched. Wild cards (*) are accepted. Multiple values could be selected from list boxes by using shift or control key.

Crop:
- ALL
- AHIPA - Pachyrhizus ahipa
- AJI - Capsicum baccatum var. pendulum
- ALFALFA - Medicago sativa subsp. sativa
- ALMOND - Prunus dulcis
- AMARANTH, PURPLE - Amaranthus cruentus

Genus name: (e.g. Oryza [without author])

Note: Only returns CWR in that genus. Select by crop to return all CWR of its crops.

Genetic relative status: ☑ primary ☑ secondary ☑ tertiary ☑ graftstock

Family(ies):
- ALL FAMILIES
- all pteridophytes
- all gymnosperms
- all angiosperms
- Abaminaceae
- Abietaceae

Native distribution:

Continent: ALL CONTINENTS Region: ALL REGIONS

Country(ies):
- ALL COUNTRIES
- Afghanistan
- Albania
- Algeria
- American Samoa

State/Province: (e.g. Alabama)

☐ **Include non-native distribution**

Restrict to crops maintained at these NPGS repositories
- ALL
- Arctic and Subarctic Plant Gene Bank - PALM
- C.M. Rick Tomato Genetics Resource Center - TGRC
- Clover collection - CLO

☐ **Restrict to names with germplasm in GRIN**

☐ **Restrict to names without germplasm in GRIN**

Search

U.S. National Plant Germplasm System

Crop Relatives in GRIN Taxonomy

(for the query: **family** = 'all families' & **native country** = 'all countries' & **crops** = 'sour cherry' & **genetic relative status** = 'GR1, GR2, GR3, GS' & **repositories** = 'all')

Follow links for a) **GRIN taxon reports** or b) **to view literature supporting this gene pool classification** (Place cursor over highlighted items for explanation.)

Crop: CHERRY, SOUR
(compiled by Dr. Blanca León)

Crop taxon:

1. ***Prunus cerasus* L.** - **sour cherry**

Crop wild relatives:

Secondary

1. *Prunus maackii* Rupr. - [Reference]

Tertiary

1. *Prunus avium* (L.) L. - [Reference]
2. *Prunus campanulata* Maxim. - [Reference]
3. *Prunus canescens* Bois - [Reference]
4. *Prunus cyclamina* Koehne - [Reference]
5. *Prunus humilis* Bunge - [Reference]

Graftstock

1. *Prunus avium* (L.) L. - [Reference]
2. *Prunus canescens* Bois - [Reference]
3. *Prunus dielsiana* C. K. Schneid. - [Reference]
4. *Prunus fruticosa* Pall. - [Reference]
5. *Prunus japonica* Thunb. - [Reference]
6. *Prunus mahaleb* L. - [Reference]
7. *Prunus padus* L. - [Reference]
8. *Prunus pensylvanica* L. f. - [Reference]
9. *Prunus dawyckensis* Sealy - [Reference]

Crop Relatives in GRIN

(for the query: **family** = 'all families' & **native country** = 'all countries' & **crops** = 'chickpe

Follow links for a) **GRIN taxon reports** or b) **to view literature supporting this gene pool**

Crop: CHICKPEA
(compiled by Dr. Blanca León; reviewed by Dr. Michael A. Grusak, USDA/ARS Children's Nutr
Western Regional Plant Introduction Station, Pullman, Washington on 18 June 2013)

Crop taxon:

1. ***Cicer arietinum* L.** - **chickpea**

Crop wild relatives:

Primary

1. *Cicer reticulatum* Ladiz. - [Reference]

Secondary

1. *Cicer echinospermum* P. H. Davis - [Reference]

Tertiary

1. *Cicer atlanticum* Coss. ex Maire - [Reference]
2. *Cicer bijugum* Rech. f. - [Reference]
3. *Cicer incisum* (Willd.) K. Maly - [Reference]
4. *Cicer judaicum* Boiss. - [Reference]
5. *Cicer pinnatifidum* Jaub. & Spach - [Reference]

Literature citations for crop relative gene pool assignment -...

https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomyliterature.aspx?tid=

Literature References for GRIN Taxonomy Crop Relative Gene Pool Assignment

Taxon

- Davies, A. M. R. et al. 2007. A natural infrageneric classification for *Cicer* (Leguminosae, Cicereae) (Blumea) 52:379-400. : [relative; this study complements Maesen et al. 2007 (Chickpea Breed Mgmt 2:14-45.) proposed taxonomy; *Cicer incisum* clustered with other two perennials (*C. atlanticum* and *C. canariense*) and in a group also including all annual species; affinities of *C. incisum* to *C. atlanticum* are supported by morphology, ISSR, AFLP, allozyme and RAPD data; this study recognized *C. incisum* in subgenus *Cicer* section *Chamaecicer*]
- Javadi, F. et al. 2007. Geographical diversification of the genus *Cicer* (Leguminosae: Papilionoideae) inferred from molecular phylogenetic analyses of chloroplast and nuclear DNA sequences Bot. J. Linn. Soc. 154:175-186. : [relative; this study examined one accession of *Cicer incisum*; all data analysis showed similar topology; combined data provided a strongly supported group including *C. incisum* and all annual species (*C. arietinum*, *C. reticulatum*, *C. echinospermum*, *C. judaicum*, *C. bijugum*) except *C. yamashitae*]
- Shan, F. et al. 2005. Geographical patterns of genetic variation in the world collections of wild annual *Cicer* characterized by amplified fragment length polymorphisms Theor. Appl. Genet. 110:381-391. : [relative; this study commented that although *Cicer anatolicum* is mostly considered to be the closest perennial species to the annual species, there is a need to clarify the perennial ancestor of the annual species in *Cicer* by adding additional accessions of each species included in phylogenetic studies; this study mentioned *C. incisum* as another candidate perennial species with a probable close affinity to annual *Cicer*]
- Sudupak, M. A. et al. 2002. Analysis of genetic relationships among perennial and annual *Cicer* species growing in Turkey using RAPD markers Theor. Appl. Genet. 105:1220-1228. : [relative; this study included one non-USDA accession representing this species; based on genetic similarities this species clustered close to group of annual species *C. pinnatifidum* - *C. bijugum*]

GRIN
CWR Data

Dr. Blanca León

https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearchcwr.aspx

GRIN-Global Project

the global
plant genebank
information management system

GRIN-Global Around the World

Rosters

- Review your Committee's roster at http://www.ars-grin.gov/npgs/index.html

References

- Refer to the data dictionary for complete descriptions of the data and dataviews
- Please visit the GRIN-Global project website, especially the Public Website and the Training & Documentation pages

Contacts

- GG Team
  - Questions / suggestions / observations / comparisons wrt GRIN & GRIN-Global
    feedback@grin-global.org
- Marty Reisinger
  - Questions related to documentation or training
    marty.reisinger@ars.usda.gov