Apple CGC Minutes
Sept 12, 2018, Geneva, NY
Plant Genetic Resources Unit Conference Room
630 West North Street, Geneva, NY 14456

Attendees: Gayle Volk (chair), Peter Bretting, Susan Brown, Ryan Callahan, Thomas Chao, Dawn Dellefave, Gennaro Fazio, Chris Gottschalk, Ben Gutierrez, Oscar Hurtado-Gonzales, Robert Jones, John Keeton, Awais Khan, Jonathan Magby, Jim McFerson, Jay Norelli, Andrew Ormerod, Cameron Peace, Greg Peck, Reece Perrin, Heidi Schwaninger, Jugbreet Sing, Bill Srmack, Dariusz Swietlik, Stijn Carlo L Vanderzande, Kenong Xu, Gan-Yuan Zhong. Phone participants: Kate Evans, Gary Kinard, Jim Luby

Opening remarks were provided to the Apple CGC by Thomas Chao and Gayle Volk.

National Program Report. (Bretting, see attached)

NPGS Training Program. (Bretting, Volk) An NPGS training program is being developed. A conference was held in Fort Collins April 24-26, 2018 to design a training program. The proposed program will likely include publicly available "learning objects" (5-15 minute segments of information), university taught web-based classes that are available to students at multiple universities and internationally, and hands-on workshops on specific topics. It will also likely have an in-service and/or continuing education component. A Higher Education Challenge Grant has been submitted to help support course development, and NPGS sites are encouraged to begin development of learning objects, with the goal of teaching specific concepts and/or techniques (contact G. Volk for more information).

NGRL Report. (Kinard, see attached) At this time GRIN-Global does not have the capacity to hold massive quantities of SNP and sequence data for collections. The Genome Database for Rosaceae is an option for data maintenance/storage/use in apple.

APHIS Report. Oscar Hurtado-Gonzales is the new APHIS contact for the status of pome (apple, pear, quince) quarantine materials. In addition to previously established molecular & phenotypic testing of accessions in quarantine, next generation sequencing protocols are under development.

Curator Report (Chao, see attached)

Highlights:
Accessions: The PGRU has 5458 field accessions with 2572 permanent field accessions and 2886 seedling accessions. There are also 1643 Malus seed accessions from 31 species with over 500,000 seeds. In the past year, new accessions were acquired from plant exploration (*M. coronaria, M. ioensis, M. sylvestris*) and contributions (*M. fusca* from University of British Columbia), and 14 *M. sieversii* accessions from J. Goffreda, Rutgers University. APHIS quarantine provisionally released 18 apple varieties and fully released 1 apple variety to the collection.

Maintenance: Field manager Bill Srmack is retiring in September 2018. He has long-term history with PGRU and remaining field crew members have been receiving hands-on training from Bill before he departs. The shrinking number of field crew members have made it difficult to collect phenotypic data on the collection. Bill Srmack was recognized by the Apple CGC for his long-term contribution to PGRU.

Distribution. The PGRU received 490 order requests, and rejected 118 of those orders in 2018. In 2017, 6837 samples were distributed, with the largest recipients being 1575 to US state agencies and all universities, 817 to USDA-ARS, 514 to US private sector companies, and 3493 to USA individuals. The cost of order processing and shipping is a concern. Of the top 50 accessions that are distributed by PGRU, many are commercially available cultivars. There was discussion of PGRU/Chao developing a list of commercially available materials and not allowing individuals to place an order for those accessions (with exceptions granted by the curator, as needed). See the list of the top 50 accessions, attached. Rather than endorsing nurseries by name, it may be preferable to generally state that they are commercially available. Note: a discussion was held at the Heritage Apple Meeting in Geneva Sept 13-14, 2018 with respect to the possible change in distribution policy. The attendees generally supported limiting the distribution of commonly available materials, so long as exceptions by the curator could be made for special cases. They also thought that nurseries would be interested in seeing the list of highly requested materials for their planning purposes.

Cryopreservation back-up. No *Malus* budwood was sent to NLGRP for back-up in 2018. 55 apple accessions that were cryoprocessed in 2017 were sent to PGRU for grafting. 34 of these accessions had 40% or greater viability.

Threats. The collection is currently threatened by some poorly-drained areas with established plantings, possible virus infections among accessions (collaboration with R. Li (NGRL) and M. Fuchs (Cornell University)), stem borer (A. Agnello), and fire blight. The group proposed that some particularly susceptible cultivars not be maintained as field accessions, especially since they have not been successfully established for over 20 years.

Impact Statement

Committee members recommended that PGRU develop an impact statement for the NPGS apple collection that would aid in outreach efforts. This statement will document 1) The impact the collection has made to stakeholders including research, breeding, NGOs, and the private sector, both nationally and internationally (distribution quantities, etc); 2) Key accessions that have had a significant impact to the above programs; 3) Listings of the most popular distributions (and purpose); and 4) Public outreach efforts. **Target date: January 31, 2019**

Proposed Subcommittees:

New Core Subcommittee: Assimilate information on utilization and distribution of the current core collection(s) (with an emphasis on the "whole collection" core).
Assess the coverage of the current core collection
Assess the need/options for replicated individuals, particularly with respect to the current space issues

Land Use Efficiency Subcommittee:

What is needed to accomplish the PGRU mission with respect to Malus conservation?
Identify a plan for using the available space
Options with respect to renewing the current PGRU lease, which will expire in ~15 years.
Assess field use strategy for existing space
Identify priorities for new acquisitions into the collections that will be maintained in the field.
Identify options for the use of future space, if more were to be made available
Identify desired crosses/population size for future pre-breeding seedling plantings

Maintenance resources necessary for future space options

Field Tour. Participants spent ~1 hour visiting the PGRU apple collection in the field.

Field space. At this time there is not a written plan with respect to the addition of new cultivars into the collection. Due to space and maintenance limitations, there is not an active pursuit of new field accessions.

Proposed planting strategy for K1: When grafting, consider using EMLA 7 x 2 trees and G890 x 2 trees. 2 will be planted in the field, and 1 eventually removed, once they are established.

W3 Block: G. Volk developed a draft plan for conserving the genetic diversity in the W3 seedling block, which currently has 1395 seedling trees. It was planted between 2000 and 2005 and has become crowded and difficult to maintain. It will be removed once the diversity in this collection is conserved (see Draft W3 plan attachment).

G1 Block: This seedling block of Gala x *M. sieversii* crosses will need to be removed in the coming years. J. Norelli has provided a recommendation of which accessions in Gala x *M. sieversii* crosses should continue to be conserved. Ongoing research projects (particularly with K. Xu) will be completed prior to its removal.

Cider & Heritage Cultivars (Peck). Key cider varieties are being imported through quarantine to provide future legal access to European varieties.

International Apple SNP Genotyping: An international project partially funded by the University of Minnesota and Carl von Ossietzky Univ., Oldenburg, Germany, and coordinated by Post-doc N. Howard is collecting and aligning SNP data to identify direct and distant pedigree relationships in apple accessions held in international apple collections, including PGRU. PGRU's participation has been limited by the funding available. At this time, 20 collections have contributed samples/data for 3205 samples (2368 of which are unique). Over 1500 accessions will be added to the project this year. From PGRU: 381 samples have been genotyped or have been collected for genotyping this year and 397 are represented by samples from other collections with identical SSR data profiles.

Global Conservation Strategy for Apple (Volk) A complete draft of the Global Conservation Strategy for Apple has been written, internally reviewed, and provided to the Global Crop Diversity Trust for feedback and finalization. Please contact G. Volk for more information.

A new European proposal: VALDIFRUIT: EU Project for Diversity in Fruit Tree Species. New project focused on providing protocols and standards to manage, organize, characterize, and conserve wild genetic resources of key fruit tree species of Rosaceae (McFerson).

Project updates were provided by A. Khan (2017 CGC Apple Evaluation Proposal Recipient), C. Peace, C. Gottschalk (for S. Van Nocker), and S. Brown.

Topic saved for future meeting: Revision of Apple Crop Vulnerability Statement

Summary/Action Items:

- Distribute meeting documents at least 1 week in advance of future meetings

- Aim to have an in-person meeting at least every other year in Geneva, with teleconferences as necessary (at least annually)
- Establish proposed sub-committees via email to include interested participants that may not be present at the CGC meeting (Volk, January 31, 2019)
- Develop/revise distribution policy to limit the distribution of commonly available materials to individual requestors (Chao, January 31, 2019)
- Develop an Impact Statement for the Apple Collection at PGRU (Chao, January 31, 2019)
- Revise and distribute W3 orchard conservation plan (Volk, October 2018)

The National Plant Germplasm System: 2018 Status, Prospects, and Challenges

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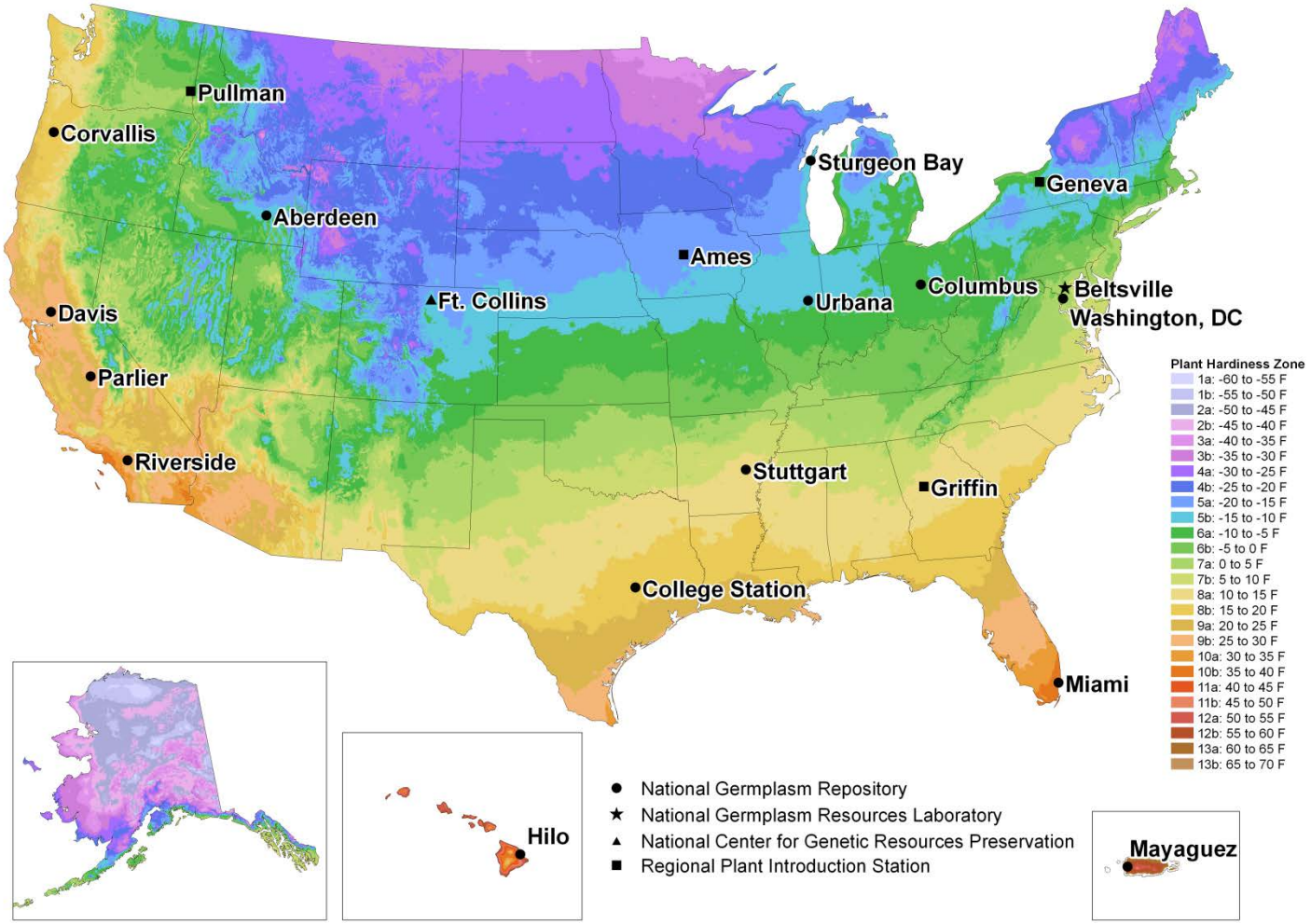
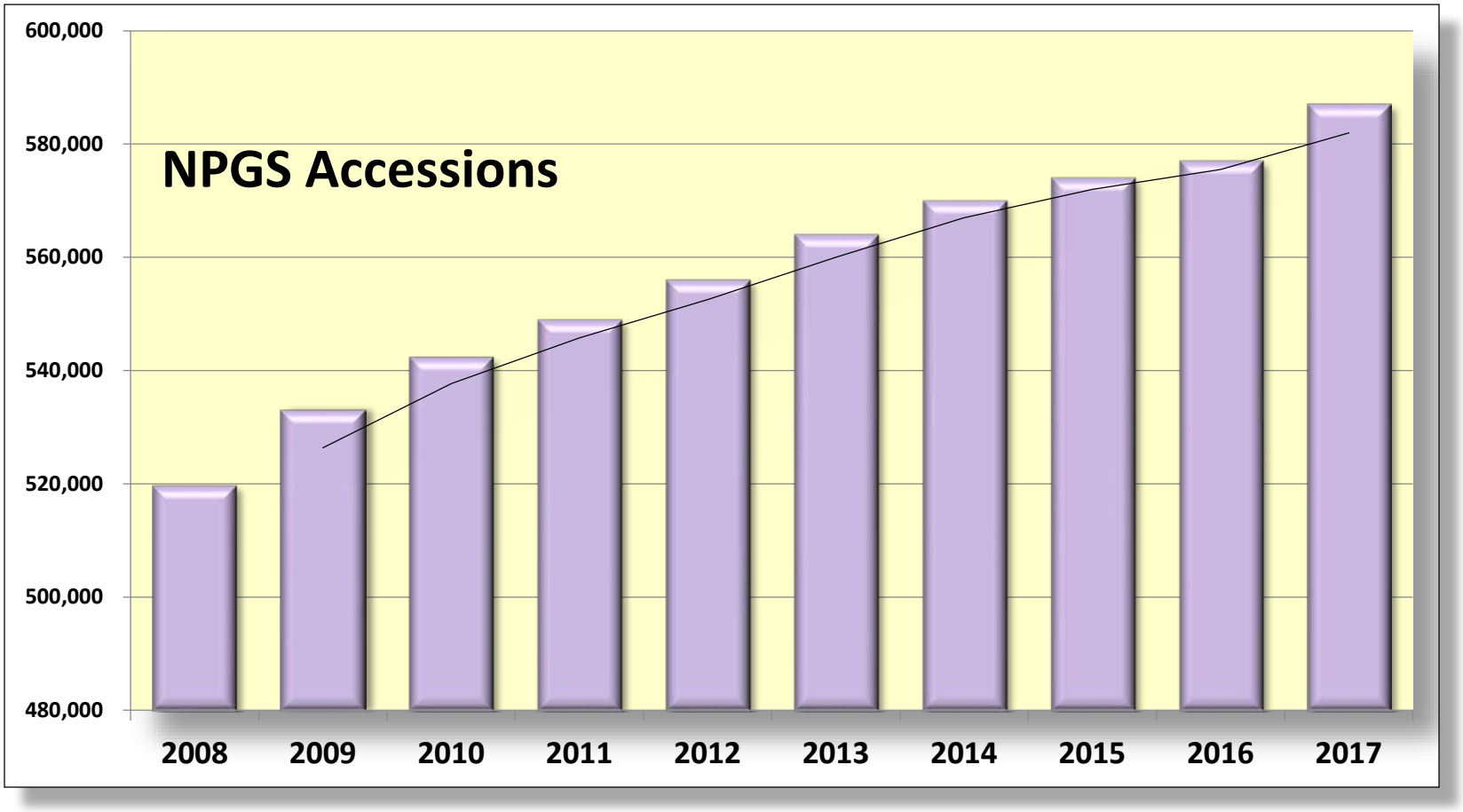
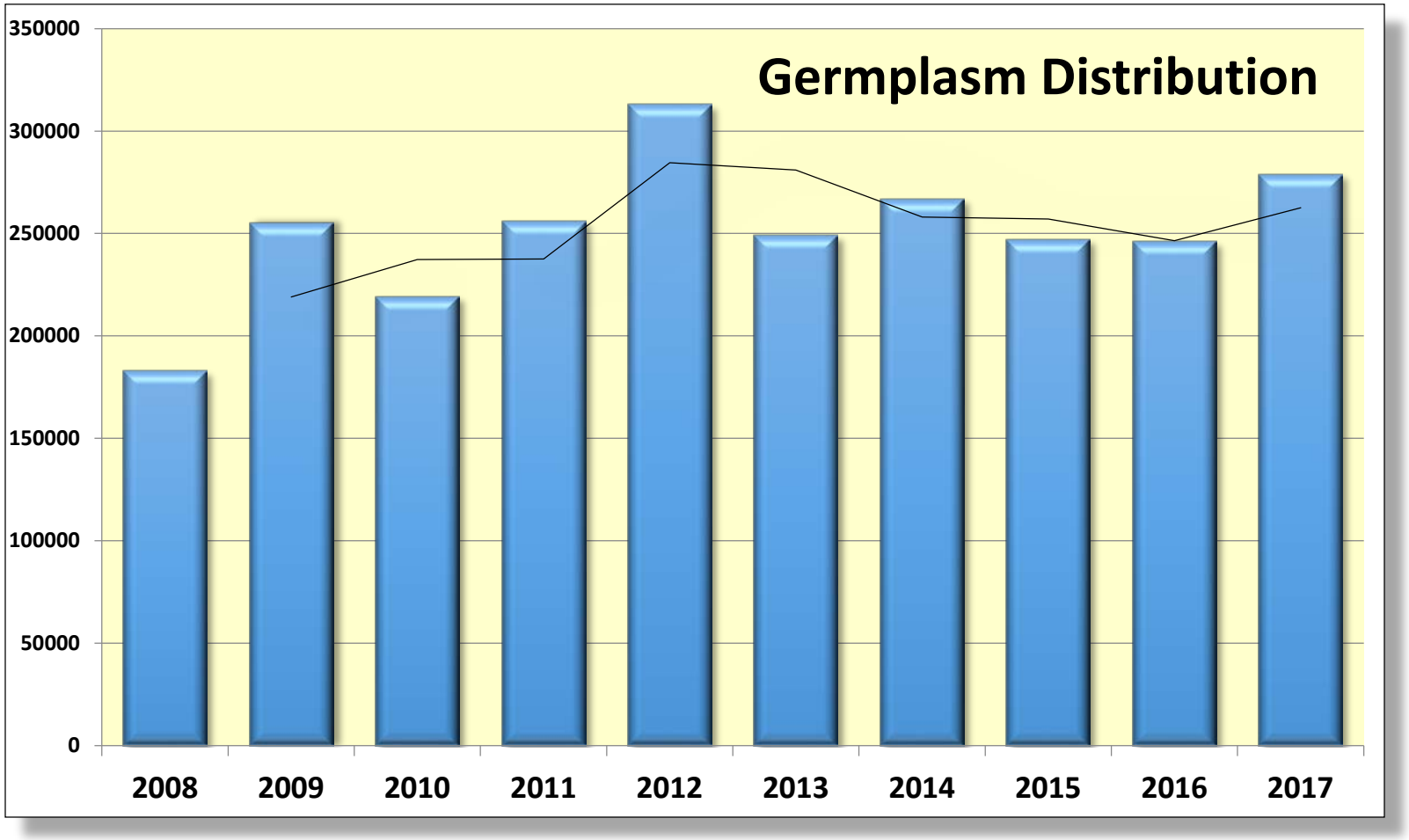
USDA National Plant Germplasm System (NPGS)



Number of NPGS Accessions 2008-2017



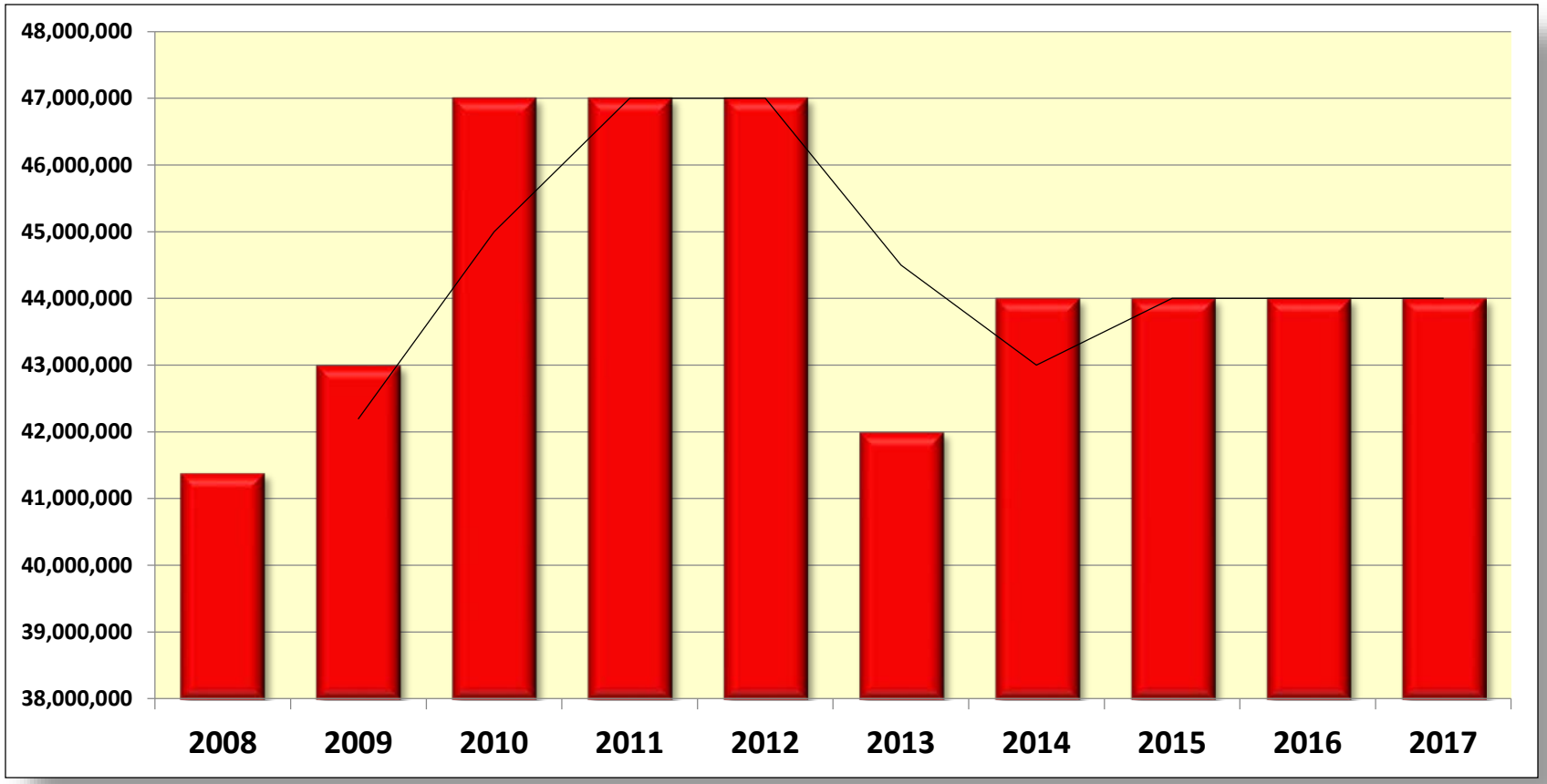
Demand for NPGS Germplasm 2008-2017



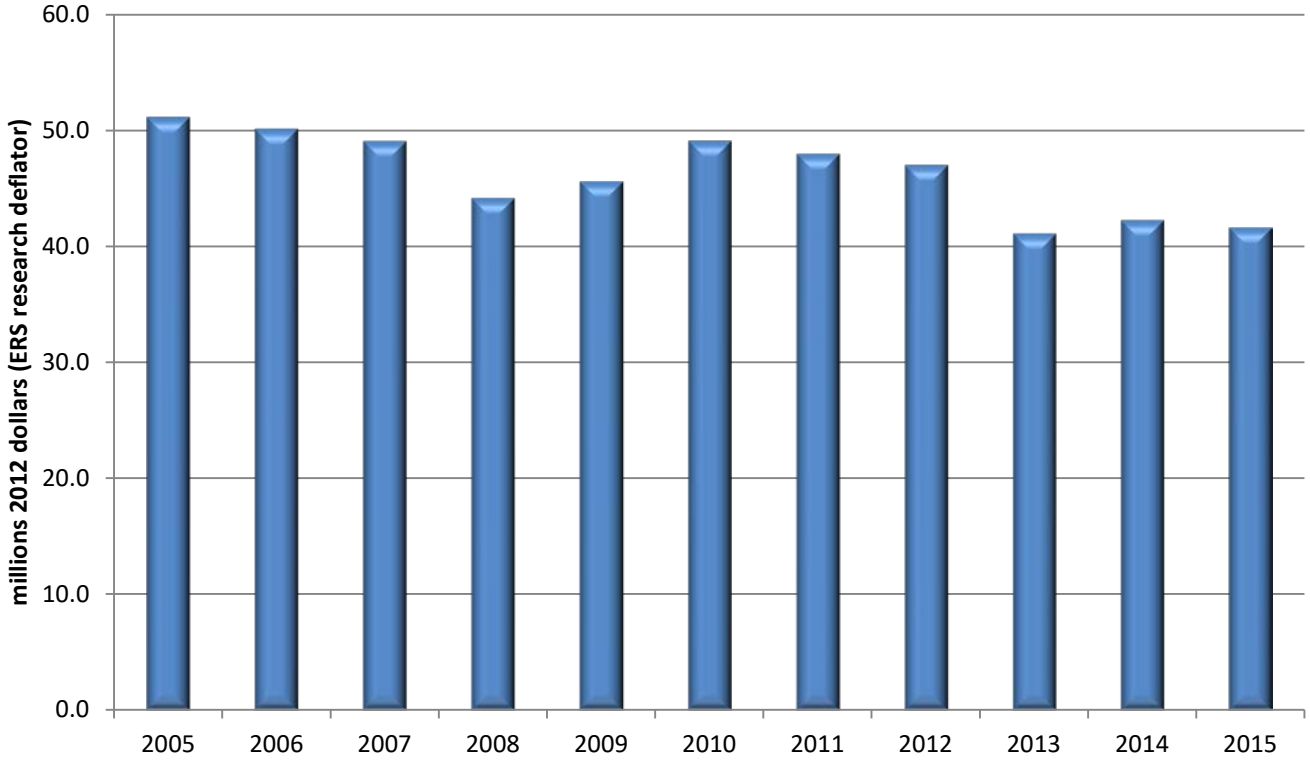
ARS National Plant Germplasm System

BUDGET

2008-2017



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 for the NPGS

- **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.**
- **Developing and applying cryopreservation and/or in vitro conservation methods for clonal germplasm.**
- **BMPs and procedures for managing accessions (and breeding stocks) with GE traits and the occurrence of adventitious presence (AP).**
- **Acquiring and conserving additional germplasm, especially of crop wild relatives.**

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 John Wiersema, (ARS-Beltsville); Dave Stout and Vicki Bradley (ARS-Pullman); Jack Peters, (ARS-Corvallis).**
- **Welcome and best wishes to Ben Gutierrez, new cold-hardy grape curator at ARS-Geneva.**
- **With hiring freeze lifted, we hope to hire additional staff in the near future.**

Plant Genetic Resource (PGR) Management Training Initiative

- **At least 1/3 of NPGS PGR managers could (likely will) retire within 5 years.**
- **Currently, no formal, comprehensive program exists for training new PGR managers.**
- **G. Volk (ARS-Ft. Collins) and P. Byrne (CSU-Ft. C.) secured a USDA/NIFA grant for a workshop at Ft. C. 24-26 April 2018 that discussed designing & developing a training program for PGR management to be delivered primarily through distance-learning.**
- **The workshop generated numerous insights; another grant proposal (Higher Education Challenge) was already submitted to extend concepts and ideas from the workshop.**

USDA-ARS
National Germplasm Resources Laboratory
Beltsville, Maryland
2018 Report to PGOC, RTACs, and CGCs

The National Germplasm Resources Laboratory (NGRL) supports the acquisition, introduction, documentation, evaluation, and distribution of germplasm by the National Plant Germplasm System (NPGS) and other components of the U.S. National Genetic Resources Program (NGRP). The Laboratory is comprised of the Plant Exchange Office (PEO), the Database Management Unit (DBMU), and the Plant Disease Research Unit (PDRU).

Plant Exchange Office

Plant Exploration and Exchange Program:

- The PEO supports the collection of germplasm for the NPGS through the management of a Plant Exploration and Exchange Program. Guidelines for developing plant exploration and exchange proposals will be distributed to CGC chairs in January 2018. Proposals must be endorsed by the appropriate CGC or other crop experts.
- The deadline for submitting proposals for explorations or exchanges to be conducted in FY 2019 is July 20, 2018.
- All foreign explorations supported by PEO comply with the Convention on Biological Diversity on access and benefit sharing related to genetic resources. Prior informed consent to collect genetic resources is obtained from the host country before the exploration. The PEO is involved in most requests to foreign governments for permission to collect and negotiates the terms of agreements when necessary.

FY 2017 NPGS Plant Explorations:

Target Crop	Country	Principal Contacts
Phalaris spp.	France	R.C. Johnson, A. Boutet
Wild apple	Austria, Romania	G. Volk, A. Cornille, T. Kirisit, A. Roman, T-M. Ursu
Herbaceous ornamentals	Georgia	M. Eristavi, T. Kurdadze
Wild raspberry	Canada	M. Dossett
Wild blueberry	United States (FL)	P. Lyrene
Wild sweetpotato	United States (FL)	L. Eserman
Wild apple	United States (IA, IL, MI, MO, PA)	T. Chao

Wild potato	United States (AZ)	J. Bamberg, C. Fernandez, A. del Rio, I. Bamberg
Wild bean	United States (AL, AR, MS, LA)	A. Egan
Blue ash	United States (KY, OH, TN)	J. Carstens

Collaboration on Crop Wild Relatives in the U.S.:

In 2016, ARS and the U.S. Forest Service established a new agreement to foster collaboration on conservation of crop wild relatives on U.S. National Forests. A pilot project on complementary (*in situ* and *ex situ*) conservation of CWR of the genetic resources of wild cranberry (*Vaccinium macrocarpon* and *V. oxycoccos*) in National Forests is underway. In 2017, leaves and germplasm of *V. oxycoccos* were collected from wild populations in National Forests in Oregon and Washington. Germplasm was sent to the National Clonal Germplasm Repository in Corvallis, Oregon. Leaf samples were sent to the ARS Vegetable Crops Research Unit at the University of Wisconsin for genetic analysis. This analysis and other factors will be used to determine which sites should be designated as *in situ* reserves.

Discovery and Documentation of Historical Plant Introductions:

A project to identify historical plant introductions (PIs) that are not in the NPGS continues. In 2017, 35 historical PIs were located at the former Cheyenne (Wyoming) Horticultural Station. The information on the PIs was distributed to curators for their input on the need to acquire samples of the germplasm.

GRIN Taxonomy for Plants:

- GRIN Taxonomy, now available through GRIN-Global (https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomyquery.aspx), provides online current and accurate scientific names and other taxonomic data for the NPGS and other worldwide users. This standard set of plant names is essential for effective management of ARS plant germplasm collections, which now represent ca. 16,150 taxa. A broad range of economically important plants is supported by GRIN nomenclature, including food, spice, timber, fiber, drug, forage, soil-building or erosion-control, genetic resource, poisonous, weedy, and ornamental plants.
- GRIN Taxonomy includes scientific names for 27,329 genera (14,386 accepted) and 1,414 infra-genera (1,352 accepted) and 109,733 species or infra-species (63,695 accepted), with over 64,717 common names, geographical distributions for 56,225 taxa, 468,112 literature references, and 31,958 economic impacts. These numbers increase regularly.
- Since 2008, a project to provide thorough coverage of wild relatives of all major and minor crops in GRIN-Taxonomy has been underway. We have completed our initial work on 190 major and minor crops from 111 genera, and an interface to query these data in various ways will be available as part of the first 2018 update of the GRIN-Global public website (test version at https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearchcwr.aspx).

We invite feedback from NPGS curators and CGC members for those CWR classifications already developed.

Facilitation of Germplasm Exchange:

The PEO helps expedite the distribution of germplasm from the NPGS to foreign scientists and other international genebanks through a long-standing collaboration with USDA-APHIS at Building 580, BARC-East. In 2017, 640 public orders containing a total of 55,912 samples of NPGS accessions were shipped from Beltsville to individuals in 69 countries around the world for research and education. In addition, PEO facilitated the agricultural inspection of arriving germplasm shipments containing accessions from numerous foreign countries for researchers and curators at NPGS sites.

Crop Germplasm Committees:

- The CGC section in GRIN (https://www.ars-grin.gov/npgs/cgcweb.html) was given a minor facelift in the transition to GRIN-Global.
- Please send updates to the individual crop CGC sections to Gary Kinard.
- Most committees continue to meet regularly and are active. Committees are particularly urged to update their Crop Vulnerability Statements and several CGCs recently completed new versions.
- A virtual meeting/web conference was held for CGC Chairs on December 1, 2016. Updates were provided on the activities of ARS and the NPGS, international issues related to plant genetic resource exploration and exchange, GRIN-Global, and the activities of the CGCs. The next meeting is scheduled for January 25, 2018.
- NGRL also has a WebEx conferencing account that is available to the CGCs to host virtual meetings (teleconference and/or webinar).

Database Management Unit

GRIN and GRIN-Global:

- At the beginning of 2018, the GRIN-Global plant database included the following:

  584,449 active accessions representing 15,720 species and 2,533 genera
  3,023,069 inventory records
  1,973,427 germination records
  8,192,598 characteristic/evaluation records
  410,476 digitized images

  These numbers increase almost daily.

- The U.S. NPGS made the transition from GRIN for plants to GRIN-Global on November 30, 2015. The GRIN-Global Development Team initiated improvements and enhancements to both the Curator Tool and Public Website, and corrected any bugs that were reported in 2017. Current information about the project, including user

documentation and release notes from each version of the software, can be found on the project website at https://www.grin-global.org/.
- Comments and suggestions about GRIN-Global can be sent to the entire development team at feedback@ars-grin.gov.

Economic Research Service Survey of NPGS Germplasm Recipients:

NGRL collaborated with the USDA Economic Research Service (ERS) to conduct a survey of more than 5300 recent global recipients of barley, beans, cotton, maize, potatoes, rice, sorghum, soybean, squash, and wheat from the NPGS. The survey closed on December 31, 2017. ERS will be analyzing the results over the next several months and preparing a report/publication on the findings.

Plant Disease Research Unit

The PDRU conducts research on pathogens that infect clonally propagated prohibited genus (i.e., quarantine) plant germplasm, including their etiology, detection, and elimination by therapeutic procedures. This project provides direct support to the APHIS Plant Germplasm Quarantine Program and helps facilitate the safe introduction, conservation, and international exchange of valuable plant germplasm. PDRU also collaborates on virus related problems with NPGS germplasm repositories, state departments of agriculture, and university scientists. Additional updates will be provided for those committees whose crops are within the scope this project's research.

Key NGRL Contacts

Research Leader
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REPORT for APPLE CGC September 12, 2018 Meeting

Plant Genetic Resources Unit, USDA-ARS
Geneva, NY 14456
Prepared by C. Thomas Chao, Horticulturist/Curator
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Malus germplasm preservation

The USDA-ARS Plant Genetic Resources Unit (PGRU) at Geneva, NY currently maintains 7,101 *Malus* collection (6,387 trees of 52 *Malus* species or hybrid species). There are 5,458 field accessions that include 2,572 permanent field accessions and 2,886 seedling accessions. There are also 1,643 *Malus* seed accessions from 31 *Malus* species with over 500,000 seeds.

Malus acquisitions and exploration

The *Malus* collection added 13,772 open pollinated seeds from 34 trees and summer budwood from 18 trees of *M. coronaria* and *M. ioensis* through plant exploration in 2017. The *Malus* collection also received one seed accession of *M. mandshurica* from National Laboratory Genetic Resources Preservation (NLGRP), USDA-ARS, Fort Collins, CO. and one seed accession of *M. fusca* from the University of British-Columbia Botanic Garden, Canada. Budwood of 14 *M. sieversii* seedling selection were sent by Dr. J. Goffreda, Department of Plant Biology, Rutgers University; these *M. sieversii* seedling selections were from the original seeds collected in Kazakhstan in mid 1990s. APHIS Quarantine Center provisionally released 18 apple varieties and fully released one apple variety to the *Malus* collection (including 13 cider apples from England, portion of the "Lady" cider apple series that highly desired by US growers and cider makers).

One plant exploration for *M. coronaria* in Pennsylvania was carried out by C.T. Chao and J. Koob from August 28 to September 1, 2017. In total, 12,261 open pollinated seeds were collected from 29 trees and budwood were collected from 12 trees at 11 locations. A second plant exploration was carried out by C.T. Chao from September 5-12, 2017 in Michigan, Illinois, Iowa, and Missouri. In total, 1,511 open pollinated seeds from 5 trees and budwood from 6 trees were collected. Most sites (20 out of 22) collected by E. Dickson in the late 1980s in these four states were lost due to urban development and land management decision. A plant exploration for collection of *M. coronaria* in Ohio was carried out by C.T. Chao from August 24-30, 2018. A plant exploration for collection of *M. doumeri* in Vietnam is planned for November, 2018 by G. Volk, NLGRP and apple curator with cooperation from the Division of Genebank Management, Plant Resources Center, Vietnam Academy of Agricultural Sciences in Hanoi, Vietnam. A plant exploration proposal for collection of *M. coronaria* and *M. ioensis* in Kentucky, Tennessee, and Arkansas in 2019 was submitted to Plant Exchange Office, National Germplasm Resources Laboratory, USDA-ARS in July 2018.

Malus germplasm distribution

For the clonal crops, a total of 428 orders (344 for *Malus*, 67 for *Vitis* and 26 for *Prunus*) for 7,074 samples (5,753 for *Malus*, 1,116 for *Vitis* and 205 for *Prunus*) were filled in 2017. From January to June 2018, the total number of order were 375 for the clonal crops. We expect the trend of increasing demand for our germplasm would continue in the near future. Significant of the request increase is attributable to the fast growing hard cider industry and growers and cider makers' desire for new cider apple varieties.

Malus germplasm cryo backup

There was no *Malus* and *Prunus* dormant budwood shipment to NLGRP for cryo-preservation in early 2018 due to the shortage of resource at NLGRP. The current focus of NLGRP is to cryo-preserve citrus germplasm collection that is under threat from the citrus greening disease (Huanglongbing, caused by Candidatus *Liberibacter* spp.). Clonal collection received budwood of 55 *Malus* and 14 *Prunus* that were cryo-treated in 2017 and shipped back to us by NLGRP on February 21, 2018. These 69 accessions were double budded onto 5 rootstocks per accession for viability testing. Thirty four *Malus* accessions had viability rate above 40% (ranging from 40% to 90%) and are acceptable for long-term cryo-preservation standard (61.82% success rate). Twenty one *Malus* accessions had viability rate below the minimum 40% viability rate (ranging from 0% to 30%) and they would need to be repeated in the future. All 14 *Prunus* had viability either 0% or 10% (2 accessions), therefore all the cryo-treatment of these 14 *Prunus* accessions would need to be repeated. We will continue working with NLGRP to backup the *Malus* and *Prunus* accessions when resources are available at NLGRP.

Other *Malus* preservation effort

We continue working with Dr. A. Agnello, Entomology, Cornell University, as one of ten sites to monitor the population of apple black stem borer (*Xylosandrus germanus*) with traps set up near the border and inside the *Malus* collection, so we could better manage this insect pest. Due to the warm spring and early summer of 2018, the trap data shows that there has been a much larger second fly of black stem borer this year. The first fly was normally much larger in number than the second fly in previous 4-5 years. The data from 2018 so far is unique. There is also significant sunburn damage to apple fruit in the collection from heat in months of June and July. There were some heavy rain fall in month of August, even flesh flooding in the collection. We continue cooperating with Dr. R. Li, plant virologist, National Germplasm Resources Laboratory, USDA-ARS and Dr. M. Fuchs, plant virologist, Plant Pathology and Plant-Microbe Biology, Cornell University on testing of virus in the *Malus* collection. We are testing more *Malus* collection for presence of viruses. We begged 75 *Malus* trees during bloom of 2018 for the production of apomictic seeds that would be used an alternative method for long-term preservation of wild *Malus* germplasm. We also investigate the possibility of preserving *Malus* pollen in liquid nitrogen by cooperating with Dr. G. Volk, NLGRP in 2018. The initial result is very promising with most *Malus* pollen samples maintain high germination rate after cryo-treatment. More pollen samples from more diverse *Malus* and *Prunus* species will be collected and tested in 2019.

We continue our cooperation with Dr. G. Peck and his students, Horticulture, Cornell University, on evaluation the fruit and juice qualities of *Malus* collection for their hard cider potential. We continue working with Dr. A. Khan, Plant Pathology and Plant-Microbe Biology, Cornell University, on studying the fire blight and apple scab diseases using the *Malus* collection and mapping of fire blight resistance genes in 7 F1s at the collection.

Personnel, fiscal, and operational Resources

Mr. P. Reece was hired as a field technician in March 2018. Mr. J. Koob, field technician, left the PGRU in early August to pursuit graduate school. Mr. B. Srmack, Farm Manager, will retire at the end of September 2018 after 35 year service at PGRU and 40 year service at Cornell University.

***Malus* related publication since February 2017**

Journal publication (6)

Gutierrez, B.L., G.Y. Zhong, S.K. Brown. 2018. Genetic diversity of dihydrochalcone content in *Malus* germplasm. Genetic Resources & Crop Evolution 65(5):1485-1502.

Gutierrez B.L., G.Y. Zhong, S.K. Brown. 2018. Increased phloridzin content associated with russeting in apple (*Malus* × *domestica*) fruit. Genetic Resources & Crop Evolution (In press).

Duan N., Y. Bai, H. Sun, N. Wang, C. Jiao, N. Legall, T. He, K. Wang, S. Jiang, H. Xu, Z. Zhang, Z. Mao, Y. Jiang, S. Wu, S. Feng, X. Chen, J. Liu, D. Wang, D. Liu, Y. Wang, C. Yin, W. Zuo, C. Liu, Y. Xu, K. Xu, C.T. Chao, G.-Y. Zhong, L. Cheng, Z. Fei, X. Chen. 2017. Genomic analyses provide new insights into apple evolution, domestication and genetic diversity. Nature Communication 8:249. www.nature.com/articles/s41467-017-00336-7.pdf

Khan, A., T. Chao. 2017. Wild apple species as a source of fire blight resistance for sustainable productivity of apple orchards. Fruit Quarterly 25(4):13 & 15-18.

Norelli, J.L., M. Wisniewski, G. Fazio, E. Burchard, B. Gutierrez, E. Levin, S. Droby. 2017. Genotyping-by-sequencing markers facilitate the identification of quantitative trait loci controlling resistance to *Penicillium expansum* in *Malus sieversii*. PloS one 12(3):e0172949.

Volk, G.M., M.M. Jenderek, C.T. Chao. 2017. Prioritization of *Malus* accessions for collection cryopreservation at the USDA-ARS national Center for Genetic Resources Preservation. Acta Hort. 1172:267-272.

Abstract (4)

Gutierrez, B., G.-Y. Zhong, S.K. Brown. 2017. Increased phloridzin content associated with russeting in apple fruit. 114TH American Society for Horticultural Science Annual Meeting, September 19-22, 2017. Waikoloa, HI.

Chao, C.T., G.-Y. Zhong. 2017. Apomixis as an alternative for preservation of wild *Malus* germplasm. 114TH American Society for Horticultural Science Annual Meeting, September 19-22, 2017. Waikoloa, HI.

Jenderek M.M, J.D. Tanner, C.T. Chao, H. Blackburn. 2018. How applicable are dormant buds in cryopreservation of horticultural woody plant crops? The *Malus* case. III International Symposium on Plant Cryopreservation, March 26-28, Bangkok, Thailand.

Wojtyna, N.C., M.G. Brown, C.T. Chao, G.M. Peck. 2018. Characteristics of 180 hard cider apple genotypes in the USDA-PGRU *Malu*s germplasm collection. 115th American Society for Horticultural Science Annual Meeting, July 30 – August 3, 2018, Washington DC.

Publication used *Malus* accessions and/or information (12)

Ballester, A.-R., J. Norelli, E. Burchard, A. Abdelfattah, E. Levin, L. González-Candelas, S. Droby, M. Wisniewski. 2017. Transcriptomic response of resistant (PI613981–*Malus sieversii*) and susceptible ("Royal Gala") genotypes of apple to blue mold (*Penicillium expansum*) infection. Frontiers Plant Sci. 8:1981. 10.3389/fpls.2017.01981

Byrne, P.F., G.M. Volk, C. Gardner, M.A. Gore, P.W. Simon, S. Smith. 2017. Sustaining the future of plant breeding: The critical role of the USDA-ARS National Plant Germplasm System. Crop Science 58: doi:10.2135/cropsci2017.05.0303

Desnoues, E., J.L. Norelli, H.S. Aldwinckle, M.E. Wisniewski, K.M. Evans, M. Malnoy, A. Khan. 2018. Identification of novel strain-specific and environment-dependent minor QTLs linked to fire blight resistance in apples. Plant Molecular Biology Reporter, pp.1-10.

Gross, B.L., M.J., Wedger, M. Martinez, G.M. Volk, C. Hale. 2018. Identification of unknown apple (*Malus* × *domestica*) cultivars demonstrates the impact of local breeding program on cultivar diversity. Genetic Resources & Crop Evolution, pp.1-11.

Harshman, J.M., K.M. Evans, H. Allen, R. Potts, J. Flamenco, H.S. Aldwinckle, M.E. Wisniewski, J.L. Norelli. 2017. Fire blight resistance in wild accessions of *Malus sieversii*. Plant Disease 101(10):1738-1745.

Migicovsky, Z. 2017. Patterns of genomic and phenomic diversity in apple and grape. Ph.D. Thesis. Pp.175.

Migicovsky, Z., M. Li, D.H. Chitwood, S. Myles. 2018. Morphometrics reveals complex and heritable apple leaf shapes. Frontiers in Plant Science 8:2185 doi: 10.3389/fpls.2017.02185

Sun, J., W.J. Janisiewicz, B. Nichols, W.M. Jurick II, P. Chen. 2017. Composition of phenolic compounds in wild apple with multiple resistance mechanisms against postharvest blue mold decay. Postharvest Biology and Technology 127:68-75.

Volk, G.M., P. Bramel. 2017. A strategy to conserve worldwide apple genetic resources: survey results. Acta Hort 1172:99-105. DOI 10.17660/ActaHortic.2017.1172.18

Volk, G.M., A.D. Henk, M.M. Jenderek, C.M. Richards. 2017. Probabilistic viability calculations for cryopreserving vegetatively propagated collections in genebanks. Genet. Resour. Crop Evolution 64:1613-1622.

Wang, M.-R., L. Chen, J.A. Teixeira da Silva, G.M. Volk, Q.-C. Wang. 2018. Cryobiotechnology of apple (*Malus spp*.): development, progress and future prospects. Plant Cell Reports:1-21. https://doi.org/10.1007/s00299-018-2249-x

Wojtyna, N. 2018. Characterization of 167 *Malus* genotypes within the USDA-ARS *Malus* germplasm collection for their potential use within the hard cider industry. Master thesis. Cornell University. Pp.143.

<u>*Malus* related outreach activities since February 2017 (20 groups, 304+ stakeholders)</u>

2017

Phone interview by Ross Courtney, Good Fruit Grower, April 25, 2017 and later reviewing the article titled " What you learn from 50 million years of apple genetic history" on June 12, 2017 issue of Good Fruit Grower. http://www.goodfruit.com/living-ancient-history

Tour of the *Malus* collection, BIOL 413 Plant-Microbe Interactions, Dr. Maryann A. Borsick Herman, Saint John Fisher College, Geneva, NY., April 27, 2017 (13 students plus professor).

Tour of the *Malus* collection, "Farm to Market: Insights into the U.S. food policy, trade and safety issues, a regional project for Europe" via U.S. State Department. Geneva, NY., May 22, 2017 (14 representatives from EU countries).

Tour of the *Malus* collection, Great Lakes Plant Breeding Initiative (GLPBI), Geneva, NY., July 14, 2017 (45 students and professors).

Tour of the Apple Collection, Hobart and William Smith College class, Dr. Elizabeth Newell, Geneva, NY., September 15, 2017 (2 professors and 20 students).

Open tour of the clonal collection, Geneva, NY., September 16, 2017 (50 stakeholders).

Tour of the clonal collection, Plant Breeding 4060 "Methods of Plant Breeding Laboratory" class, Professor Mark E. Sorrells, Cornell University, Geneva, NY., September 16, 2017 (21 professor, students, and fellows).

Tour of the Apple collection, "Sustainable Living and Learning Community" class, Hobart and William Smith College, Dr. Beth Kinne, Geneva, NY., September 27, 2017 (30 students plus

two professors).

Tour of the Clonal collection, Drs. Sun Lei, Xu Haiying, Beijing Academy of Forestry and Pomology Sciences, Dr. Mu Weisong, College of Information and Electrical Engineering, China Agriculture University, Beijing, and Dr. Liu Yanlin, College of Enology, Northwest A&F University, Shannxi, China. Geneva, NY., October 10, 2017 (6 visitors).

Tour of the clonal collection, "Fruit Sciences" class, SUNY Cobleskill, Dr. Daniel Weber, Geneva, NY., October 12, 2017 (11 students plus professor).

Tour of the *Malus* collection, Florent Geerdens, Rene Nicolai Nursery, Belgium, Willy Dillen, ABCz, Brelgoium; Heather Brandt, and Kevin Brandt, Brandt's nursery, California, Geneva, NY., October 13, 2017.

Tour of the clonal collection, Dr. Jeremy Thompson, PLSCI4940, "Molecular diagnostics, from lab to viñedo", Geneva, NY., October 14, 2017 (20 students plus a lecturer, a professor, and a Cornell University photographer – part of an course long photographic documentation).

Host of the interview by CBS Sunday Morning show, reporter Mo Rocca and crews, plus Phil Forsline (former curator) and Dr. Herb Aldwinckle (Plant Pathology and Plant-Microbe Biology, Cornell University) at the *Malus* collection, Geneva, NY., October 17, 2017 (6 visitors). https://www.cbsnews.com/news/was-johnny-appleseed-for-real/

Tour of the *Malus* and *Vitis* collection, Dr. Steve van Nocker and 4 students, Horticulture, Michigan State University, Geneva, NY., October 13, 2017 (5 visitors).

Tour of the *Malus* collection, Professor Lailiang Cheng, Horticulture section, School of Integrated Plant Science, Cornell University, and 10 researchers, extension agents, and growers from Shandong Province, China sponsored by Walmart Foundation, Geneva, NY., December 4, 2017 (11 total).

2018

Tour of the USDA Clonal collection, Professor Derek Linton, "Plants and Empire" class, Hobart and William Smith Colleges, Geneva, NY., April 20, 2018 (15-20 students plus professor).

Host visit of the Apple collection, Dr. Courtney Hollender plus two graduate students, Michigan State University, Geneva, NY., May 31, 2018 (3 visitors).

Host visit of the Apple and Tart Cherry collections by Nature Source Improved Plants, LLC, Dr. Steve Tanksley and 3 others, Geneva, NY., June 6, 2018 (4 visitors).

Host tour of the *Malus* and Tart Cherry collection, Professor Herb Aldwinckle and Marcela Yepes, Cornell University, NSF STEM Outreach program targeting minority students (high school and rising undergraduates) funded by National Science Foundation (NSF) Plant Genome Research Program (PGRP), Geneva, NY., June 26, 2018 (6 students, 1 TA, and 2 scientists).

Host tour of the PGRU, Regina Clinton, Department of Biology, SUNY Geneseo, Geneva, NY., August 1, 2018. (1 lecturer).

Other *Malus* related research that PGRU supports

Clonal collection is currently supporting following research project: (1) Apple breeding at Cornell University, University Minnesota, and Washington State University-S. Brown, J. Luby, K. Evans and C. Peace; (2) RosBREED II, multiple PIs and Institutions; (3) Apple rootstocks breeding against abiotic stresses, pests and diseases-G. Fazio, PGRU; (4) Evaluation of cryptic flowering in the *Malus* collection and evaluation of *Malus* accessions for hard cider potential-S. van Nocker, C. Hollender, Michigan State University; (5) Genetic and genomics of fruit quality

and tree architecture traits of *Malus*-K. Xu, Cornell University; (6) Deeping sequencing, genome duplication and polyploidization in *Malus ioensis*, *Malus angustifolia* and *Malus coronaria*-L. Yant, John Innes Center, J. Higgins, University of Leicester, S. Mathews, CSIRO, N. DaCosta, Harvard University, T. Chao, PGRU; (7) Detection of virus in the *Malus* collection-R. Li, National Germplasm Resources Laboratory, USDA-ARS and M. Fuchs, Cornell University; (8) RNA seq study of factors affecting cryo-preservation of *Malus* dormant budwood– G. Volk, NLGRP and PGRU; (9) Importation and evaluation of new Spanish and English cider apples-I. Merwin, G. Peck, Cornell University; (10) Cryopreservation of *Malus* pollen-G. Volk, NLGRP; (11) Evaluation of *Malus* collection for potential hard cider production and genetic of acidity in hard cider apples-G. Peck, K. Xu, Cornell University, T. Chao, PGRU; (12) Allele mining for fire blight and apple scab resistance genes in the *Malus* collection-A. Khan, Cornell University, L. Candle-Davison, GGRU, and J. Norelli, AFRS; (13) Bitter pit evaluation using *Malus* collection-L. Cheng, B. Orcheski, Cornell University; (14) Open-pollinated families with low coverage sequencing for identification and fine mapping of fire blight resistance in apples-Khan, Cornell University; (15) Importation of international apple scab monitoring varieties-A. Khan, Cornell University, APHIS and PGRU; (16) Screening and identifying new fire blight resistance genes in wild *Malus*-A. Khan, Cornell University and PGRU; (17) Mapping of fire blight resistance genes in F1 populations-A. Khan, Cornell University and PGRU; (18) Trapping and monitoring of apple black stem borer-A. Agnello, Cornell University; (19) Production trials of new hard cider varieties in AZ, CA, GA, ME, MI, MT, NM, NY, WA and WV; (20) Rescue and evaluation of “extinct” apple varieties in the deep South-S. Mihm, University of Georgia and T. Chao, PGRU; (21) Bark tissue of *M. tschonoskii* for research on extracting yellow dye used in traditional Japanese painting-S. Mori, Freer and Arthur Sackler Galleries, Smithsonian; (22) Genotyping of heirloom apple varieties using RosBREED SNP array-N. Howard, J. Luby, University of Minnesota, G. Peck, Cornell University, D. Albach, University of Oldenburg, G. Volk, NLGRP and T. Chao, PGRU; (23) Feral domestic apples study in Ontario, Canada-B. Husband, P. Kron, University Guelph; (24) Genetic study of apple ripening, R. Beaudry and P. Engelgau, University of Illinois, Urbana-Champaign.