The Critical Role of International Collaborations to Improve Conservation and Utilization of Crop Collections

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INTERNATIONAL YEAR OF
FRUITS AND VEGETABLES
2021

Vegetatively Propagated Collections

Propagated by grafting or cuttings, rather than from seeds

Genebank maintenance in fields, greenhouses/screenhouses, or in tissue culture

High economic value, nutritious, add variety to diets, and provide job opportunities for local and/or international consumption



Vegetatively Propagated Collections

Offer high levels of novel diversity that is often not available in other genebank collections

Materials are difficult (or impossible) to transfer across international (and some state) borders, often making accessions irreplaceable

May have limited numbers of associated research/breeding programs

Highly susceptible to abiotic and biotic threats

Inadequately secured at secondary locations

Fewer available technical resources (propagation, in vitro methods, etc)

USDA National Plant Germplasm System

597,773 accessions representing 2552 genera

Seed propagated: 557,263 (92.8%)

Clonally propagated: 40,510 (7.2%)

- Fruits & nuts: 69 crops with 26,935 accn
- Vegetables: 5 crops with 2439 accn
- Grasses: 9 crops with 871 accn
- Other (cacao, hops, rubber): 6 crops with 722 accn
- Ornamentals: 74 genera with 9543 accn

GRIN-Global Public Website: https://npgsweb.ars-grin.gov/gringlobal/search

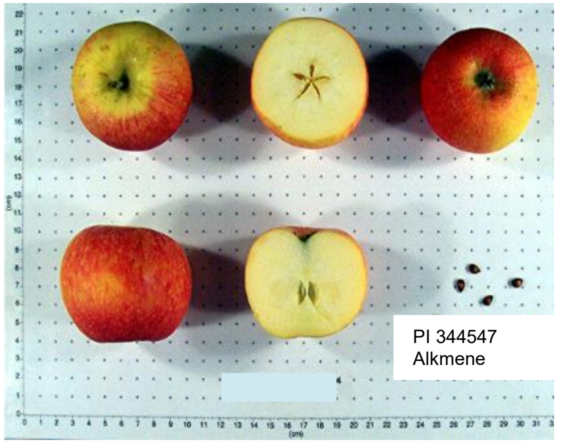
USDA- Plant Genetic Resources Unit in Geneva, NY

2569 grafted trees (modern, historic, cider, crab, wild species)
3209 wild seedlings and crosses
1533 seed accessions

35 *Malus* species, 15 hybrid species

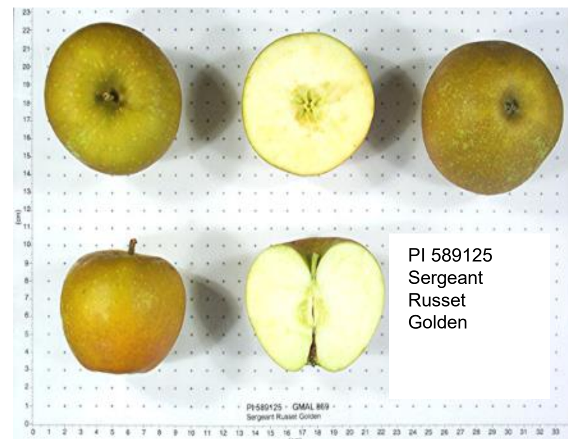
- Genotyped diploid cultivars using 9 SSRs

Identified 238 sets of synonyms



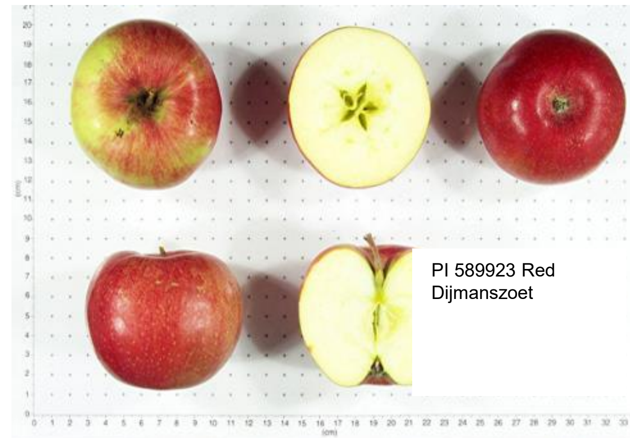
Gross et al. 2012

Identified 23 sport families, represented by 104 individuals



Gross et al. 2012

Identified Rootstock escapes: Scions match rootstocks



Gross et al. 2012

HortScience 44(3):589–594. 2009.

Identification of Historic Apple Trees in the Southwestern United States and Implications for Conservation

Kanin J. Routson[1]
Arid Lands Resource Sciences, University of Arizona, 1955 East Sixth Street, P.O. Box 210184, Tucson, AZ 85719

Ann A. Reilley, Adam D. Henk, and Gayle M. Volk
National Center for Genetic Resources Preservation, U.S. Department of Agriculture, Fort Collins, CO 80521

Capitol Reef National Park

DOI: 10.1002/ppp3.10152

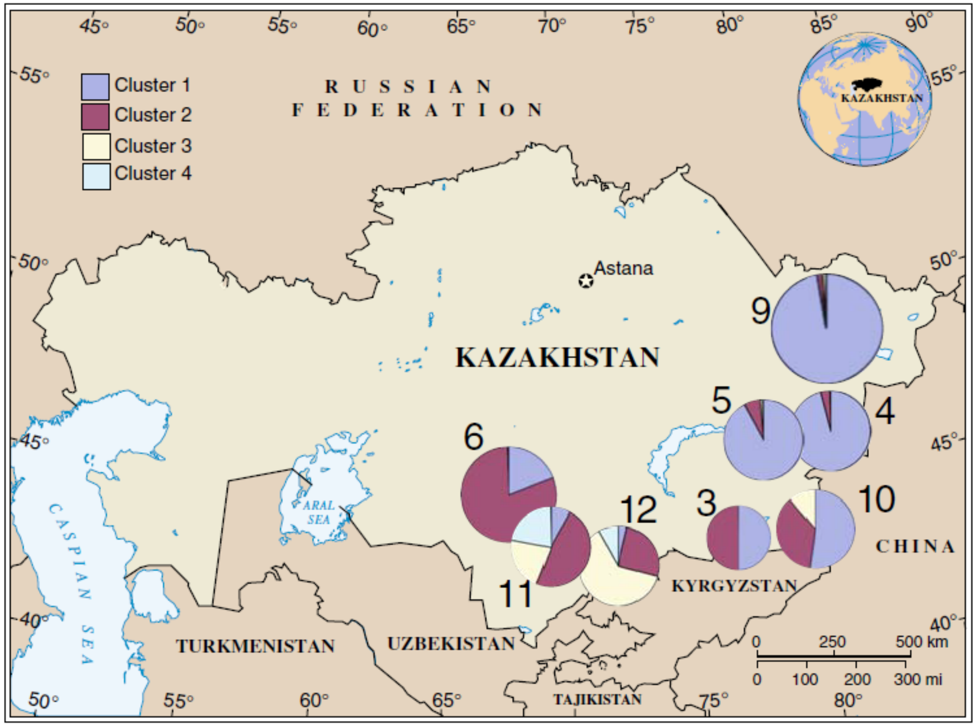
RESEARCH ARTICLE

Plants People Planet PPP
Open Access

Genetic data inform Yosemite National Park's apple orchard management guidelines

Gayle M. Volk[1] | Jonathan Magby[2] | Adam Henk[1] | Steven Miller[2] | Rachel Mazur[3]

Diversity and conservation of progenitor species *Malus sieversii* in Central Asia



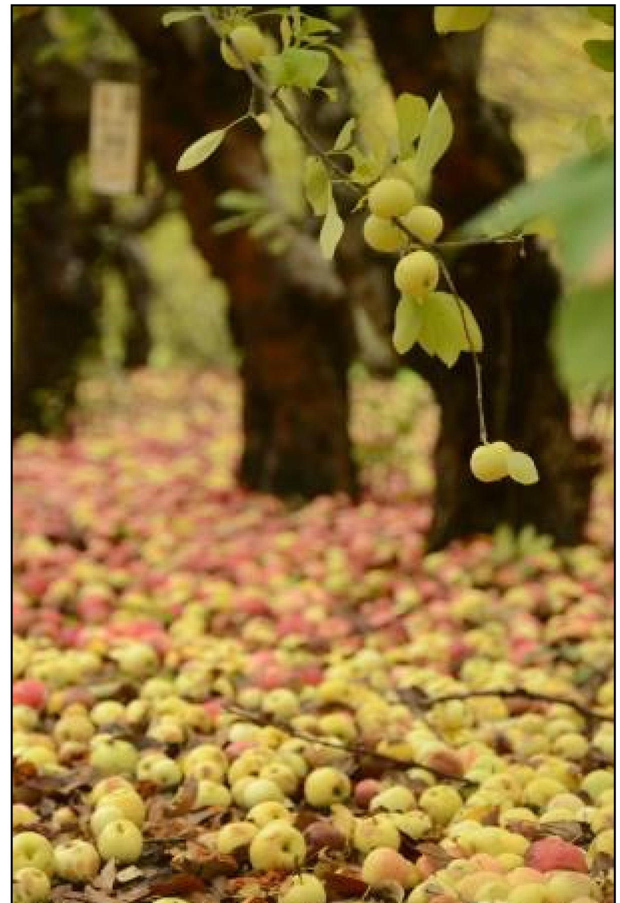
Caspian University

Genet Resour Crop Evol (2015) 62:765–794
DOI 10.1007/s10722-014-0194-2

RESEARCH ARTICLE

The vulnerability of US apple (*Malus*) genetic resources

Gayle M. Volk · C. Thomas Chao · Jay Norelli · Susan K. Brown · Gennaro Fazio · Cameron Peace · Jim McFerson · Gan-Yuan Zhong · Peter Bretting



Apple Plant Explorations

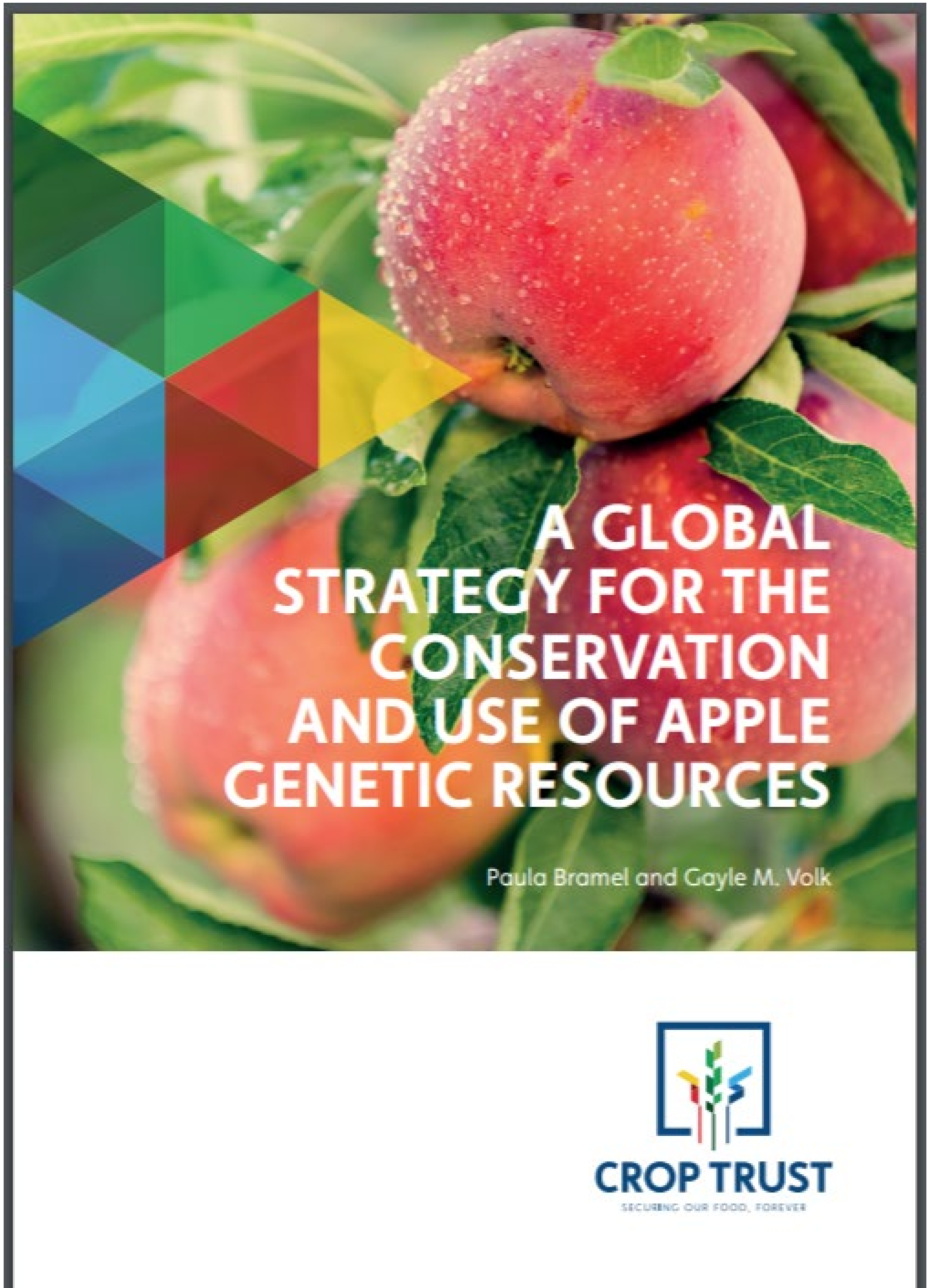
2017, *Malus sylvestris*
Romania and Austria

A. Cornille, A. Roman, T. Ursu, T. Kirisits

Apple Plant Explorations

2018 *Malus doumeri,*
Vietnam

T. T. Hoai, N. Kien



https://cdn.croptrust.org/wp/wp-content/uploads/2019/11/Apple-Conservation-Strategy.pdf

Survey: 35 Apple Collection Inventories

65	Albania
437	Azerbaijan
1545	Belarus
1773	Belgium
82	Bosnia and Herzegovina
388	Brazil
287	Canada
1011	China
65	Czech Republic
20	Egypt
2191	France
1343	Germany
215	Greece
1210	Hungary
204	India
220	Ireland
130	Israel
256	Italy-Udine
40	Italy-Valor
1350	Japan
38	Kazakhstan
698	Latvia
937	Lithuania
400	New Zealand
429	Poland
3821	Russia
119	Slovenia
520	South Africa
191	Spain
550	Sweden
1300	Switzerland
173	The Netherlands
330	Turkey
2247	United Kingdom
5291	USDA

Total: 29,876 *ex situ* accessions, mostly *M.* x *domestica*

Apple Collection Conservation—On a Global Scale

- Worldwide apple production is dominated by 10-20 cultivars
- Crop vulnerability to diseases, pathogens, and environmental threats
- Apple crop wild relatives possess some desirable traits, but access to materials is a challenge
- Quarantine restrictions
- Clonal collections are expensive

Global Conservation Plan for Apple

- Documented international network of collections with agreed-upon standard procedures
- Conserve cultivars as clones in multiple collections/field sites
- Information database to document passport, availability, fingerprint, phenotype, image information
- Possible seed conservation to conserve wild species diversity
- A combination of international and local cultivars with unique traits/characteristics
- Replicate local cultivars in multiple collections for safety duplication

Opportunities with the 20K Apple SNP array

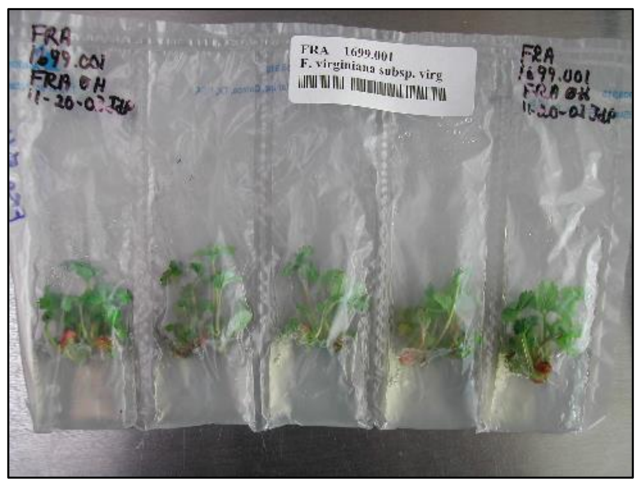
Collection comparisons (>25 international collections participating)
Pedigree information
Linked to markers for breeding
Synonyms
Trueness-to-species (particularly for close crop wild relatives)
Cultivar identities

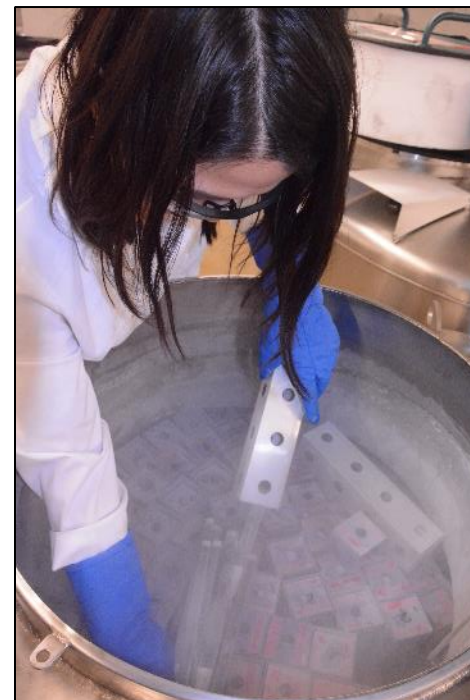
- Genotyped 1400+ USDA-NPGS apple accessions using the SNP array

N. Howard, J. Luby, C. Peace. C.-E. Durel, etc.

Securing Clonal Collections is Expensive, but Critical

- Duplicated plantings/locations
- Seeds for CWR species representatives
- Reduced temperature storage in tissue culture
- Cryopreservation (long-term storage in liquid nitrogen) for cultivars





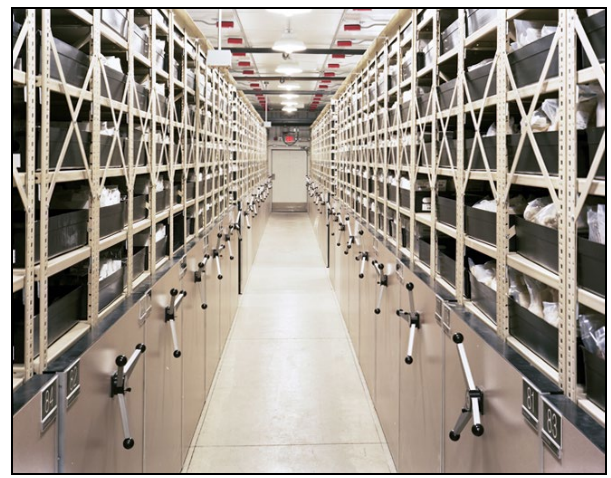
National Laboratory for Genetic Resources Preservation
Fort Collins, CO

Secured at NLGRP:

82% of ~600,000 NPGS seed accessions

15% of the 30,000 NPGS clonal fruit, nut, and vegetable accessions

LN & LNV (-150 to -196^{o}C) for clonal shoot tips & dormant buds, as well as embryonic axes, some seeds, and pollen



-18^{o}C Freezers, seed storage

NLGRP Clonal Cryopreservation Research and Implementation

Dormant buds from cold-hardy perennials: Apple, sour cherry, willow

Shoot tips excised from field or greenhouse-grown plants: Citrus, garlic

Shoot tips excised from tissue cultured plants: Grape, strawberry, potato, etc.

Cryopreserved clonal crops in NPGS

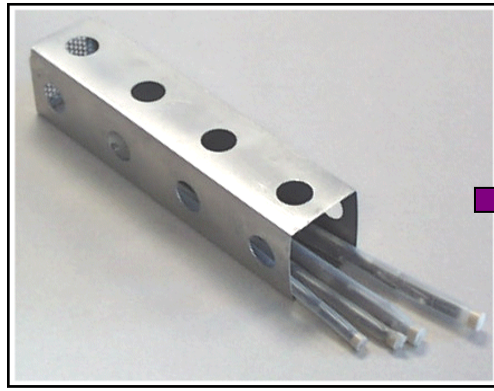
Shoot tips	
Garlic	102
Strawberry	98
Hops	88
Sweet potato	151
Mint	42
Banana	22
Pear	221
Currants	96
Raspberry	202
Potato	430
Blueberry	41
Sugarcane	28
Citrus	400

Dormant buds	
Apple	2052
Sour cherry	32
Willow	19

4024 accessions cryopreserved

M. Jenderek

Dormant bud cryopreservation



Harvest budwood, desiccate to 25-30% moisture,
Package in polyolefin tubes

Slow cool to –30
LN_2 plunge and store

LN storage

Thaw, Rehydrate

Assess viability

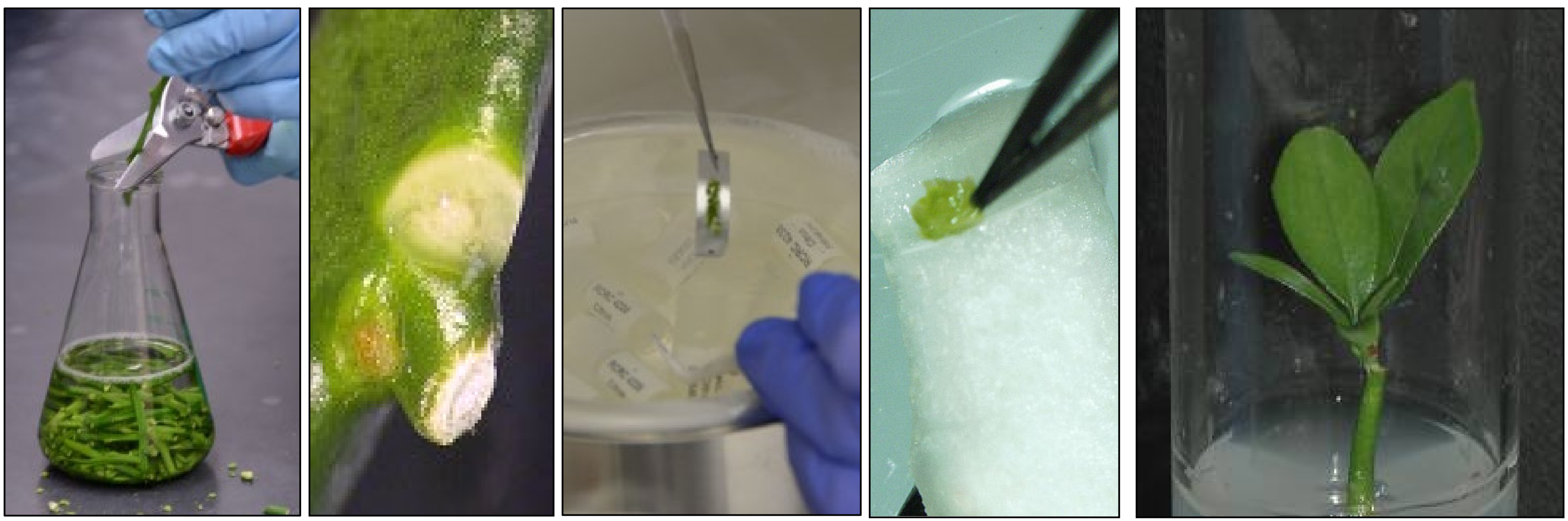
Apple Dormant Bud Cryopreservation

2052 NPGS apple accessions representing 49 taxa
Cryopreserved in Fort Collins 1988-2014

M. Jenderek

Citrus shoot tip cryopreservation

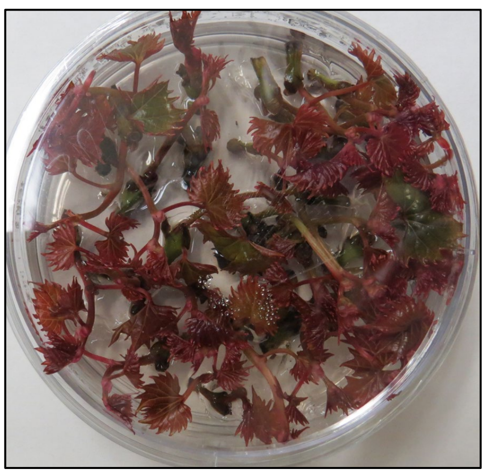
- Technology developed by NLGRP & Riverside in 2012
- Shoot tips (1 mm) excised from screenhouse-grown trees
- Surface-sterilized, treated with cryoprotectants, cryopreserved
- Recovered by micrografting
- 400 Citrus accessions cryopreserved at NLGRP

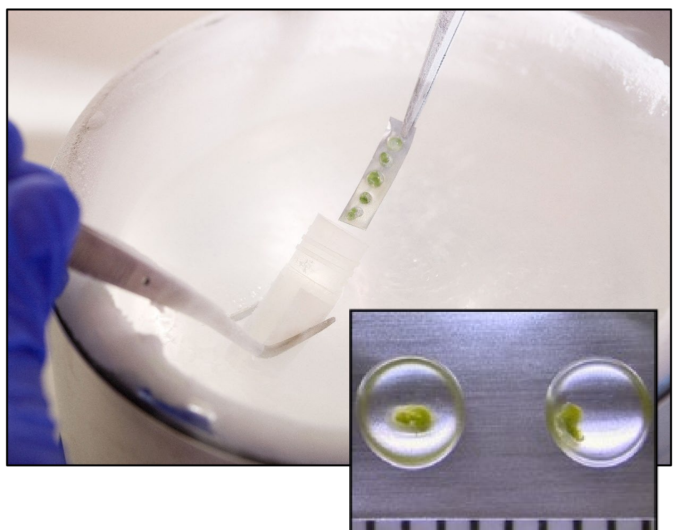


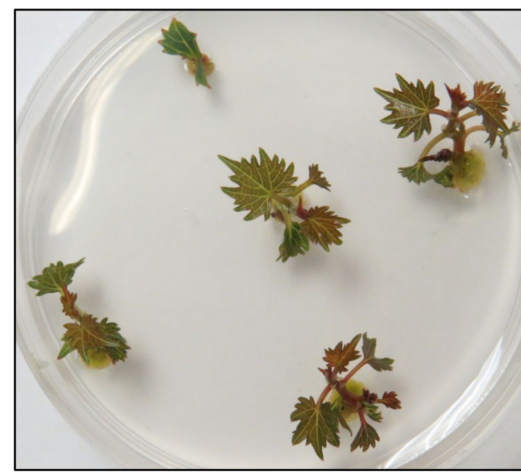
R. Krueger, R. Lee, M.-L. Polek, M. Jenderek

Vitis shoot tip cryopreservation

- Cultivars introduced into tissue culture
- Shoot tips (1 mm) excised from in vitro nodal sections
- Treated with cryoprotectants, cryopreserved
- Recovered by plating onto medium
- 20 Vitis accessions cryopreserved at NLGRP



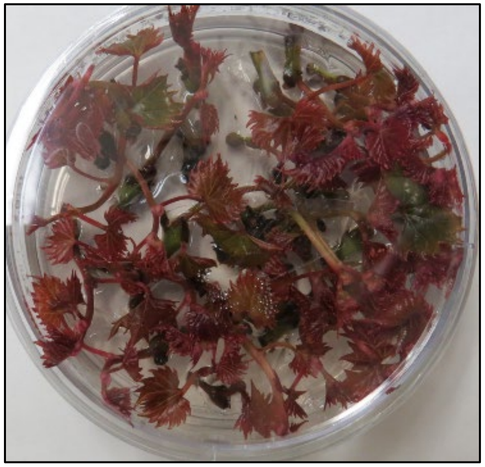
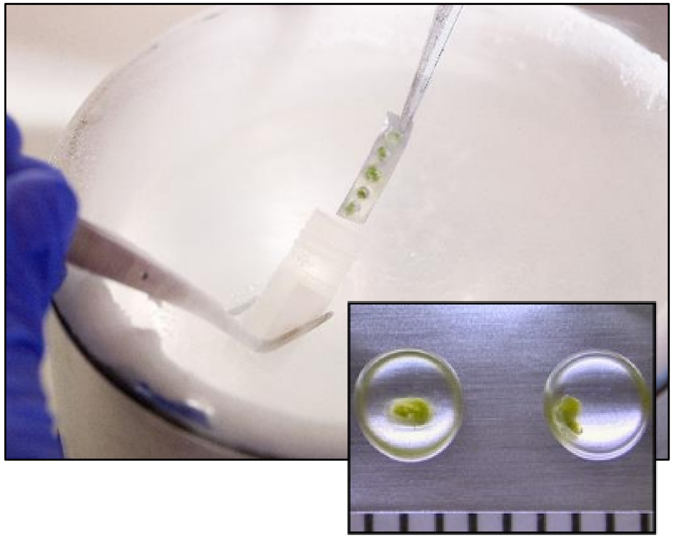




J.C. Bettoni

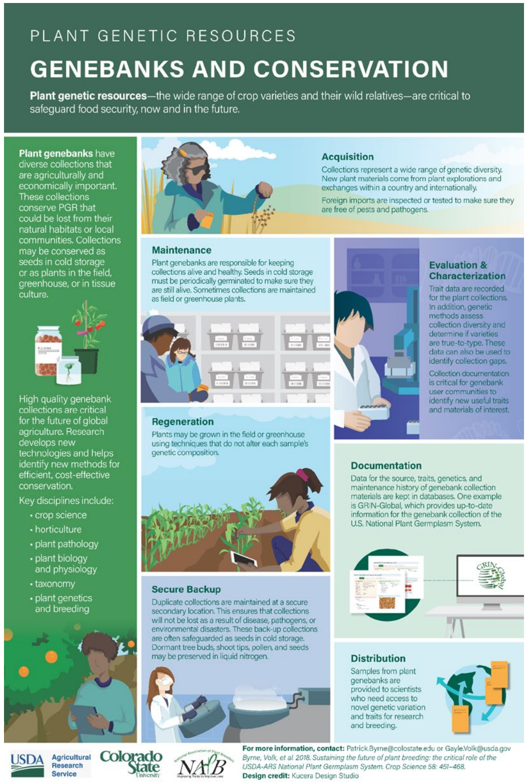
Challenges for Cryopreserving Clonal Collections

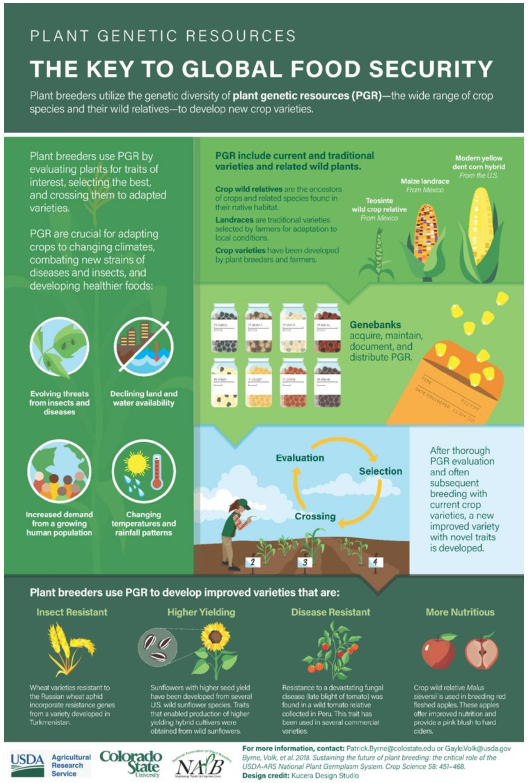
- Facilities
- Specialized skills/training
- Labor intensive
  - 60-75 accessions/year/tech for shoot tips
  - 200+ accessions/year/tech for dormant buds
- Sufficient plant material (quantity, quality/endophytes)
- Tissue culture & cryopreservation methods available & tested


Training Program
Plant Genetic Resources Management and Use

- Funded by a NIFA-Higher Education Challenge Grant with Colorado State, Iowa State and USDA
- Training materials will be freely available through new site associated with GRIN-Global: ebooks, videos, images, virtual tours, PDFs
- Online courses will be offered through Colorado State Univ





Temporary Website: http://genebanktraining.colostate.edu/trainingmaterials.html

P. Byrne, C. Gardner, M. Munoz-Amatriain, J. Zarestky, W. Suza, G. Kinard, D. Namuth-Covert, G. Morris, K. Jewell

Additional Resources for Clonal Cryopreservation

Bettoni JC, Bonnart R, Volk GM. 2020. Challenges in implementing plant shoot tip cryopreservation technologies. Plant Cell, Tissue and Organ Culture. https://doi.org/10.1007/s11240-020-01846-x

Tanner JD, Chen KY, Bonnart RM, Minas IS, Volk GM. 2020. Considerations for large-scale implementation of dormant budwood cryopreservation. Plant Cell, Tissue and Organ Culture. https://doi.org/10.1007/s11240-020-01884-5

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Field Tour of the USDA National Clonal Germplasm Repository for Tree Fruit, Nut Crops, and Grapes in Davis, California

Gayle M. Volk and John E. Preece

Public Domain

READ BOOK

Crop Wild Relatives and their Use in Plant Breeding

Gayle Volk and Patrick Byrne

Public Domain

READ BOOK

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Coming Down the Learning Resources Pipeline…

More ebooks:
Applications of Plant Pathology in Genebank Collections
Fundamentals of Plant Genebanking
Phenotyping
Genomics for Genebanks

More virtual tours:
Crop diversity: A Virtual Crop Science Field Tour
National Laboratory for Genetic Resources Preservation

More infographics:
The Role of Botanic Gardens in Plant Conservation

An official website:

Temporary Website: http://genebanktraining.colostate.edu/trainingmaterials.html

Conclusions

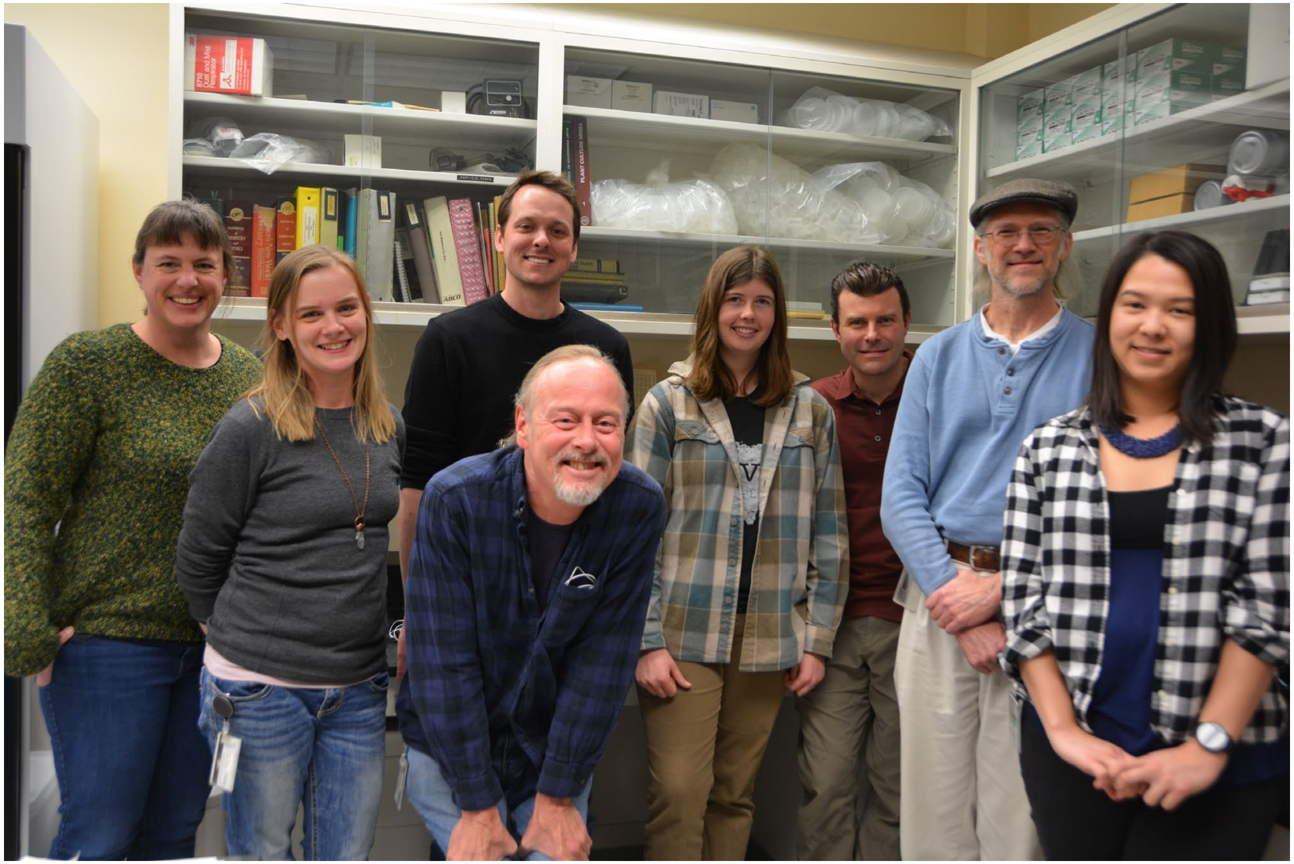
NPGS has many vegetatively propagated collections throughout the genebank system

Expensive to maintain and very vulnerable

International collaborations are needed to build and characterize the collections

Creative, novel back-up strategies are needed to preserve these genetic resources now and into the future

Freely available training content will educate the current and future genebanking community



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