



RosBREED

Annual Project Report



United States
Department of
Agriculture

National Institute
of Food and
Agriculture

*Dedicated to the
genetic improvement
of U.S. rosaceous
crops*
www.rosbreed.org

RosBREED Advisory Panel
Annual Meeting
January 11, 2018
San Diego, CA

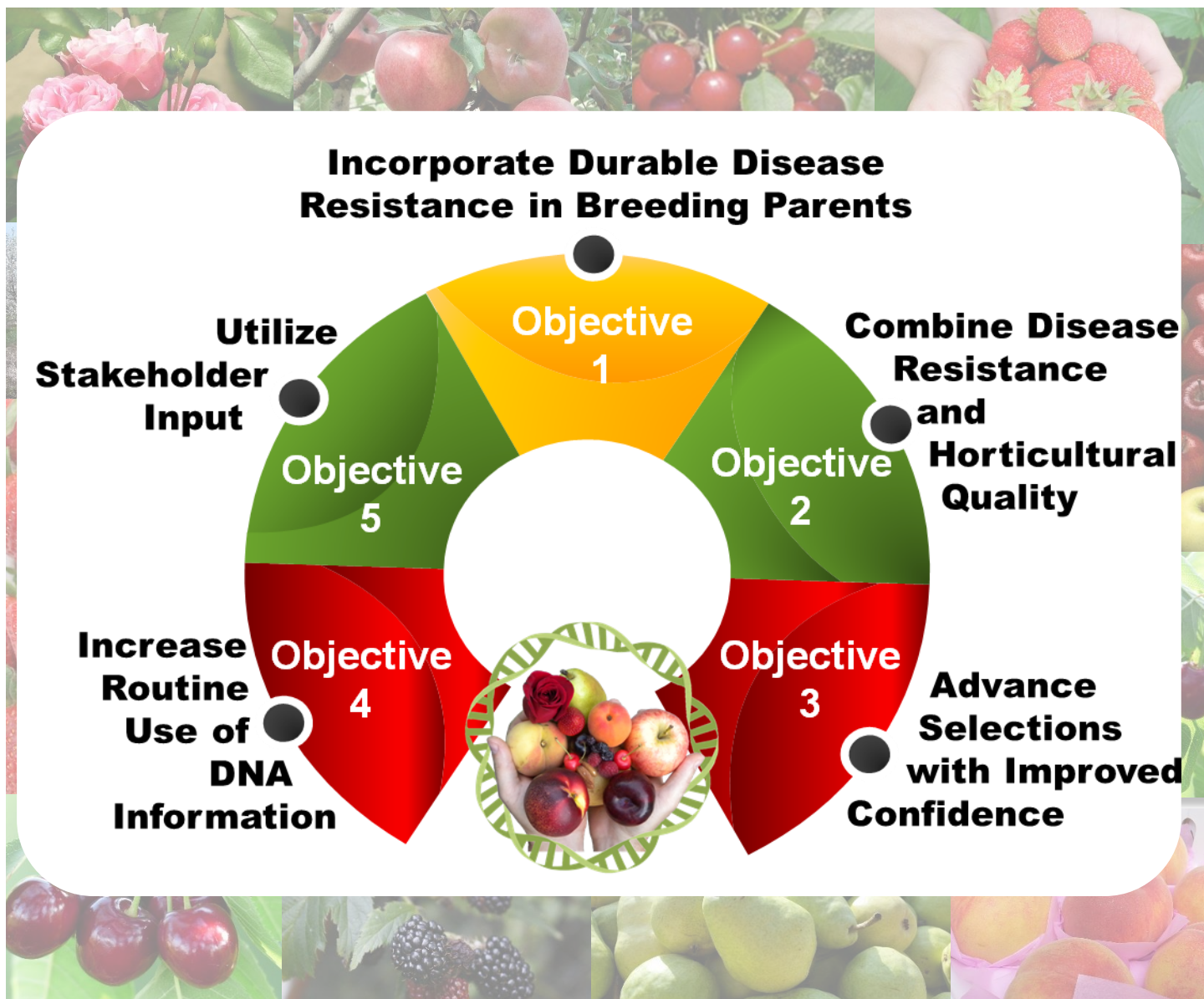




Table of Contents

Content Description	Page
Agenda	3
Team Leaders	4
Team Members	5
International Partners and Nature of Partnership	6
Advisory Panel Members – Industry	7
Advisory Panel Members – Scientific	8
Advisory Panel Members – Extension	9
Project Overview	10
Crops, Breeders, and Diseases Targeted	11
Objective 1	12
Objective 2	13
Objective 3	14
Objective 4	15
Objective 5	16
DNA Test Tables	17
Obj 1 YR 3 Deliverables, Challenges, & YR 4 Planned Deliverables	20
Obj 2 YR 3 Deliverables, Challenges, & YR 4 Planned Deliverables	22
Obj 3 YR 3 Deliverables, Challenges, & YR 4 Planned Deliverables	24
Obj 4 YR 3 Deliverables, Challenges, & YR 4 Planned Deliverables	26
Obj 5 YR 3 Deliverables, Challenges, & YR 4 Planned Deliverables	29
RosBREED Breeders' Annual Report for Year 3 - Summary	31
Break-Out Session Discussion Questions	33



Agenda

Thu, Jan 11, 2018
Skyline/Lindbergh Rooms (Ninth Floor)
Hilton San Diego Airport, 1960 Harbor Island Dr., San Diego, Calif.

Start	End	Audience/ group	Presenter/ moderator	Title
7:30	8:00	Continental breakfast		
8:00		All	Amy lezzoni	Introductions and Agenda
8:30		All	Amy lezzoni	Project overview
8:50		All	Team Leaders	Obj. 1: Incorporate durable disease resistance into breeding parents
9:20		All	Team Leaders	Obj. 2: Combine disease resistance and horticultural quality
9:40		All	Team Leaders	Obj. 3: Advance selections with improved confidence
10:00	10:30	Break		
10:30		All	Team Leaders	Obj. 4: Increase routine use of DNA information in rosaceous crop breeding
11:00		All	Team Leaders	Obj. 5: Utilize stakeholder input
11:30		All	Amy lezzoni	Budget
11:45		All	Amy lezzoni	Charge for afternoon breakout groups
12:00	1:30	Lunch		
1:30	2:45	Breakout groups by crop	Group 1	Pome Fruit (Skyline/Lindbergh Rooms)
			Group 2	Stone Fruit (Chart Room – 1 st floor)
			Group 3	Berry and Rose (Port Room – 1 st floor)
2:45	3:15	Break		
3:15	4:00	All	Breakout group moderators	Report-outs & discussion – next steps/action items
4:00	5:00	All	Cameron Peace	Round table
5:00	Dinner on your own or in working groups			

RosBREED

Combining Disease Resistance
with Horticultural Quality
in New Rosaceous Cultivars



Team Leaders

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RosBREED Team Members

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Breeder Collaborators

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RosBREED Project Assistants

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International Partners and Nature of Partnership

- 1. Centro di Ricerca per la Frutticoltura, Rome, Italy:** Ignazio Verde provides expertise in peach genomics, genetics, and QTL discovery.
- 2. Department of Plant Breeding and Genetics, East Malling Research, East Malling, UK:** Richard Harrison provides expertise in strawberry genetics and genomics. Felicidad Fernandez provides expertise in cherry and pear breeding and genetics.
- 3. INRA – Breeding & Genetics teams:** The INRA breeding teams provide parallel expertise in apple, peach, strawberry and cherry breeding and genetics.
 - a. Unité de Génétique et Amélioration des Fruits et Légumes (UGAFL), INRA CR Beauouze, France**
INRA – Angers: Francois Laurens and team member Charles-Eric Durel provide expertise in apple breeding and genetics and collaborate by using common SNP markers. Linkages are formed with the molecular genetics laboratory of Pauline Lasserre.
 - b. Unité de Recherche des Espèces Fruitières (UREF), INRA CR, Villenave d'Ornon, France**
INRA – Bordeaux: Béatrice Denoyes-Rothan provides expertise in strawberry breeding and genetics and collaborates by placing the RosBREED SNP markers on the INRA octoploid strawberry map. Elisabeth Dirlwanger provides expertise in *Prunus* genetics and comparative mapping in the Rosaceae. José Quero-Garcia provides expertise in sweet cherry breeding and genetics and we are collaborating by using common SNP markers.
 - c. Unité de Génétique et Horticulture (GENHORT), INRA CR, Avignon, France**
INRA – Avignon: Benedicte Quilot-Turion provides expertise in peach molecular genetics and collaborates by using common SNP markers. Linkages are formed with the peach breeding team of Thierry Pascal and Patrick Lambert.
- 4. Institut für Pflanzengenetik, Leibniz University Hannover, Germany:** Thomas Debener provides expertise in rose genetics and genomics including access to a large collection of unpublished ESTs.
- 5. CREA - Research Centre for Viticulture and Enology, Roma, Italy:** Riccardo Velasco provides expertise in genomics and supports RosBREED through the sharing of refinements in the apple genome sequence.
- 6. Institut de Recerca i Tecnologia Agroalimentàries (IRTA), Cabrils, Spain:** Pere Arús provides expertise in peach genetics and genomics. Amparo Monfort provides expertise in strawberry genetics and genomics as part of the international strawberry SNP consortium.
- 7. Instituto de Investigación y Formación Agraria y Pesquera, Málaga, Spain:** Iraida Amaya provides expertise in strawberry genetics, genomics, germplasm and breeding.
- 8. Plant & Food Research, Palmerston North, New Zealand:** Sue Gardiner provides expertise in apple and pear genetics and marker-assisted breeding. David Chagné provides expertise in apple and pear genetics, including genome-wide selection.
- 9. University of Chile, Santiago, Chile:** Herman Silva and Lee Meisel provide expertise in Rosaceae functional genomics and metabolomics through the sharing of peach, sweet cherry, and strawberry sequence data.

Professional Interests of RosBREED Advisory Panel Members

RosBREED has three Advisory Panels, representing industry, scientific, and extension interests. Panel members broadly represent the diversity of Rosaceae by crop, region, and professional expertise.

RosBREED Industry Advisory Panel

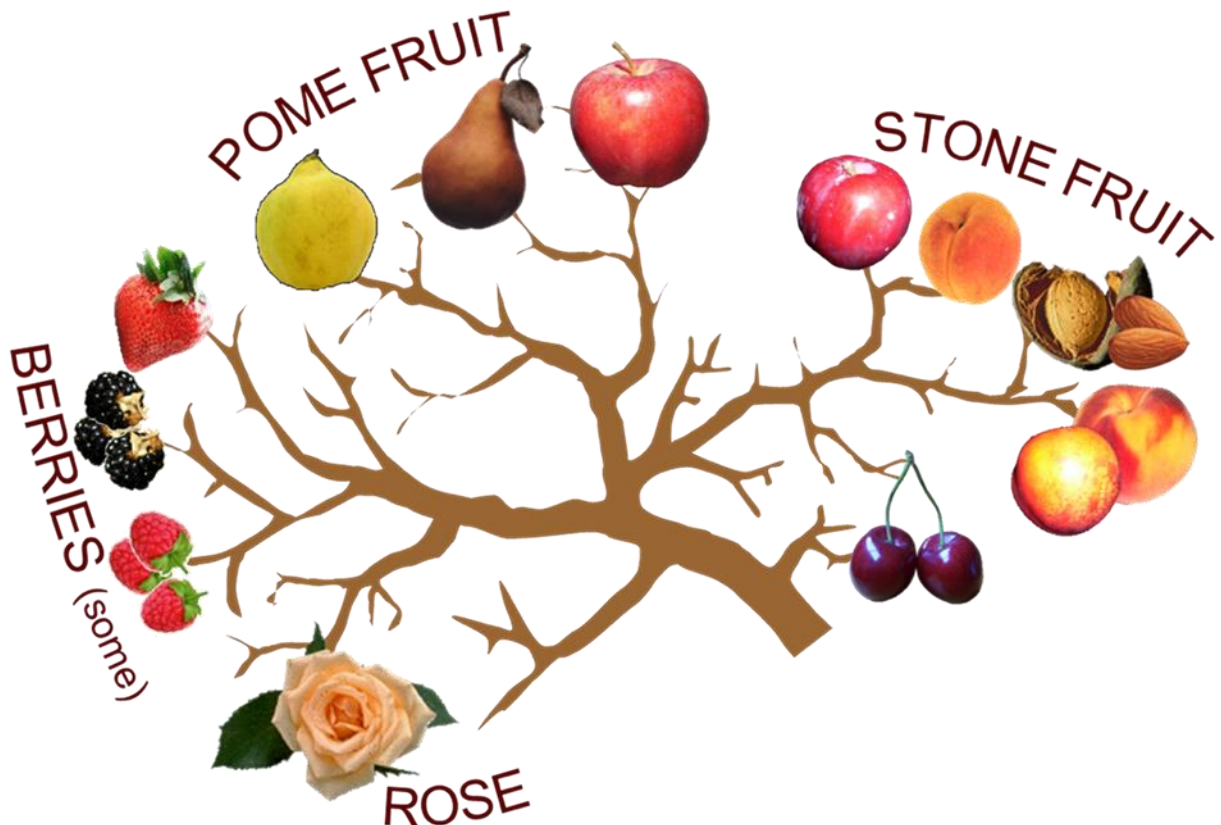
- **Jim Allen:** Vice President
New York Apple Sales, Glenmont, NY (www.newyorkapplesales.com/)
- **Jen Baugher:** Marketing Associate
Adams County Nursery, Aspers, PA (www.acnursery.com)
- **Chalmers Carr III:** CEO
Titan Peach Farms, Inc., Ridge Spring, SC (www.titanfarms.com)
Board of Directors, South Carolina Peach Council (www.scpeach.org)
- **Robert Curtis:** Senior Director, Agricultural Affairs
Almond Board of California, Modesto, CA (www.Almonds.com)
- **Bill Dodd:** President
Ohio Fruit Growers Marketing Association, Newcomerstown, OH
(www.ohioapples.com/ohio_apples_fgma.htm)
ex-President Board of Trustees, US Apple Association
- **Carlos Fear:** Director of Consumer Lab and Molecular Genetics
Driscoll's Strawberry Associates, Watsonville, CA (www.driscolls.com)
- **Bob Gix:** Horticulturist
Blue Star Growers, Cashmere, WA
Co-Chair, Fresh Pear Research Subcommittee, Pears USA (www.usapears.com)
- **Bruce Grim:** Director
Washington Marketing Associations, Wenatchee, WA (www.themarketingassociations.org)
ex-President, Board of Trustees, US Apple Association
- **Cynthia Haskins:** President/CEO
New York Apple Association, Inc. (www.nyapplecountry.com)
- **Philip Korson:** President
Cherry Marketing Inst., Inc., Lansing, MI (www.choosecherries.com)
- **John Lott:** President
Bear Mountain Orchards, Inc., Aspers, PA
- **Mercy Olmstead:** Senior Research Manager
Research and Education, California Strawberry Commission, Watsonville, CA
(www.calstrawberry.com)
- **Michele Scheiber:** Director of Breeding
Star Roses and Plants, West Grove, PA

RosBREED Scientific Advisory Panel

- **Pere Arús:** Head, Plant Genetics Dept., Institut de Recerca i Tecnologia Agroalimentàries (IRTA), Cabrils, Spain
Research areas: molecular tools for plant genetics; comparative genomics and application of molecular markers in Rosaceae breeding. (www.irta.cat/ca-ES/Persones/Pagines/105.aspx)
- **Joe Arvai:** Max McGraw Professor of Sustainable Enterprise and Director, Erb Institute, University of Michigan, Ann Arbor, MI
Research areas: Behavioral decision research and decision support systems (www.snre.umich.edu/profile/joseph_Arvai)
- **Frederick Bliss:** Professor Emeritus, Univ. of California, Davis and Sr. Director (ret.), R&D Special Projects, Seminis Vegetable Seeds, Woodland, CA
Research areas: genomics, genetics, and breeding of fruit and vegetable crops; research administrator in public and private sectors; commercialization of breeding products
- **Robin Buell:** Professor, Dept. of Plant Biology, Michigan State Univ., East Lansing, MI
Research areas: genomic aspects of plant biology and plant pathogens; high throughput sequencing, functional genomics, comparative genomics, and bioinformatics (www.plantbiology.msu.edu/faculty/faculty-research/robin-buell/)
- **Lailiang Cheng:** Professor, Dept. of Horticulture, Cornell Univ., Ithaca, NY
Research areas: plant nutrition, fruit physiology, molecular, cellular, and whole plant response to abiotic stress in apple, cherry, grape; undergraduate and graduate education (<http://hort.cals.cornell.edu/people/lailiang-cheng>)
- **Susan Gardiner:** Principal Scientist, The Horticultural and Food Research Inst. of New Zealand (Plant & Food Research [PFR])
Research areas: leads Gene Mapping Team integrated with PFR breeders in several Rosaceae crops, including, apple, apple rootstock, pear, peach/nectarine and apricot
- **Kim Hummer:** Supervisory Research Horticulturist, USDA-ARS National Clonal Germplasm Repository, Corvallis, OR
Research areas: conservation and genetics of fruit, nut, and specialty crops; ploidy in strawberry species..
- **Dan Kluepfel:** USDA-ARS & Professor, Dept. of Plant Pathology, UC Davis, CA
Research areas: bacterial diseases of almonds and walnuts, specifically crown gall. (<http://plantpathology.ucdavis.edu/?story=1033>)
- **Brad Rickard:** Assoc. Professor, Dept. of Agricultural Sciences, Cornell Univ., Ithaca, NY
Research areas: economic implications of policies, innovation, and industry-led initiatives applied to agricultural and food markets (<http://dyson.cornell.edu/people/profiles/rickard.php>)
- **Carolyn Ross:** Assoc. Professor, Dept. of Food Science, Wash. State Univ., Pullman, WA
Research areas: sensory analysis and consumer preferences of fruit and fruit products, including fresh and processed apple, pear, and cherry and wine. (<http://sfs.wsu.edu/personnel/faculty-staff/ross-c/>)
- **Phil Simon:** Research Geneticist, USDA-ARS and Professor, Dept. of Horticulture, Univ. of Wisconsin-Madison, Madison, WI
Research areas: vegetable breeding and genetics; biochemistry of culinary and nutritive factors, terpenoids, and sugars in carrots and garlic. (www.ars.usda.gov/pandp/people/people.htm?personid=5186)
- **Chang-Lin Xiao:** Supervisory Research Plant Pathologist. USDA-ARS, Parlier CA
Research areas: biology, epidemiology, and management of diseases of fruit crops with an emphasis on postharvest diseases. (www.ars.usda.gov/pandp/people/people.htm?personid=47587)

RosBREED Extension Advisory Panel

- **David Eddy:** Editor, American/Western Fruit Grower, MeisterMedia, Willoughby OH
Professional interests: Ag journalism, print and electronic communication
(www.growingproduce.com/author/david-eddy/)
- **Peter Hirst:** Professor, Dept. of Horticulture, Purdue Univ., West Lafayette, IN
Professional interests: tree fruit production systems and physiology, physiological genetics of flowering and fruit development in Rosaceae; state Extension specialist; undergraduate and graduate education
(<https://ag.purdue.edu/hla/Pages/Profile.aspx?strAlias=hirst&intDirDeptID=16>)
- **David Karp:** Associate, Agricultural Experiment Station, UC Riverside, Riverside, CA
Professional interests: freelance food journalist and photographer
- **Ron Perry:** Professor, Dept. of Horticulture, Michigan State Univ., East Lansing, MI
Professional interests: extension and research in cherry and apple orchard systems
(<http://www.hrt.msu.edu/ronald-perry/pg7>)
- **Clark Seavert:** Professor & Director of the NW Agribusiness Executive Seminar Department of Agricultural & Resource Economics, Oregon State Univ., Corvallis, OR
Professional interests: assessment and advancement of technologies that increase profitability and feasibility in commercial agriculture, with the aim of aligning business model innovation strategies to existing and future technologies.
(<http://arec.oregonstate.edu/seavert>)
- **Chris Watkins:** Professor, Dept. of Horticulture, Cornell Univ., Assoc. Director for Cornell Cooperative Extension, Ithaca, NY
Professional interests: postharvest physiology and management of apple, pear, peach, and cherry; state-wide agricultural extension activities
(<http://hort.cals.cornell.edu/people/christopher-watkins>)



RosBREED

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What is RosBREED?

RosBREED is a multi-state, multi-institution project dedicated to the genetic improvement of U.S. rosaceous crops by targeted applications of genomics knowledge and tools to accelerate and increase the efficiency of breeding programs.

This Coordinated Agricultural Project is funded through the USDA-NIFA Specialty Crop Research Initiative by a combination of federal and matching funds, grant 2014-51181-22378.

What stakeholder and consumer needs does RosBREED address?

The perfect cultivar of apple, cherry, peach, strawberry, rose, and other rosaceous crops, one which consistently exceeds consumer expectations with satisfying appearance, aroma, flavor, shelf life, and texture AND also meets industry needs for durable disease resistances and productivity, remains elusive.

Yet, such rosaceous cultivars are possible. The components exist – but they must be combined.

What is our vision?

Combining horticultural quality, durable disease resistances, and productivity into new cultivars can be achieved through the coordinated application and implementation of new scientific advances.

What does success look like?

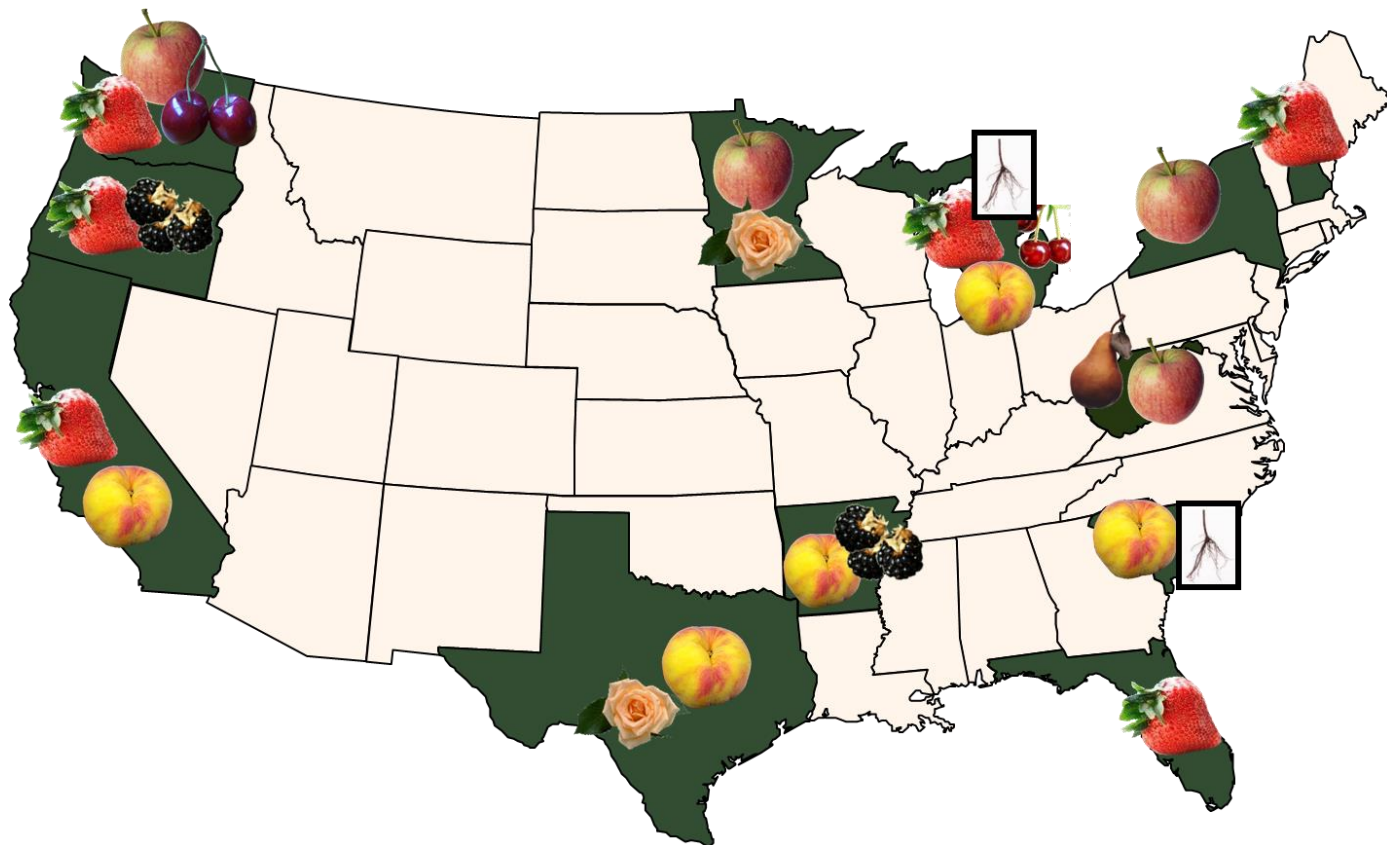
- Consumers are satisfied, repeat customers
- Rosaceous crop industries are more profitable and sustainable
- Plant breeding programs are more efficient and effective

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Targeted Crops, Breeders, & Diseases



Apple: Apple scab, Blue mold, Fire blight

- Washington State Univ. (Kate Evans)
- Univ. of Minnesota (James Luby)
- Cornell Univ. (Susan Brown)
- USDA-ARS Kearneysville (Jay Norelli)

Peach (scion & rootstock): Bacterial spot, Brown rot, *Armillaria* root rot

- Clemson Univ. (Ksenija Gasic)
- Univ. of Arkansas (Margaret Worthington)
- Texas A&M (David Byrne)
- Univ. of California Davis (Tom Gradziel)
- Michigan State Univ. (William Shane)

Pear: Fire blight

- USDA-ARS Kearneysville (Jay Norelli)

Sweet cherry: Powdery mildew

- Washington State Univ. (Cameron Peace)

Tart cherry (scion & rootstock): Cherry leaf spot, *Armillaria* root rot

- Michigan State Univ. (Amy Iezzoni)

Rose: Black spot

- Univ. of Minnesota (Stan Hokanson)
- Texas A&M Univ. (Dave Byrne)

Strawberry: Root and Crown rots, Bacterial angular leaf spot

- Michigan State Univ. (James Hancock)
- USDA-ARS Corvallis (Chad Finn)
- Univ. of Florida (Vance Whitaker)
- Univ. of New Hampshire (Tom Davis)
- Washington State Univ. (Pat Moore)

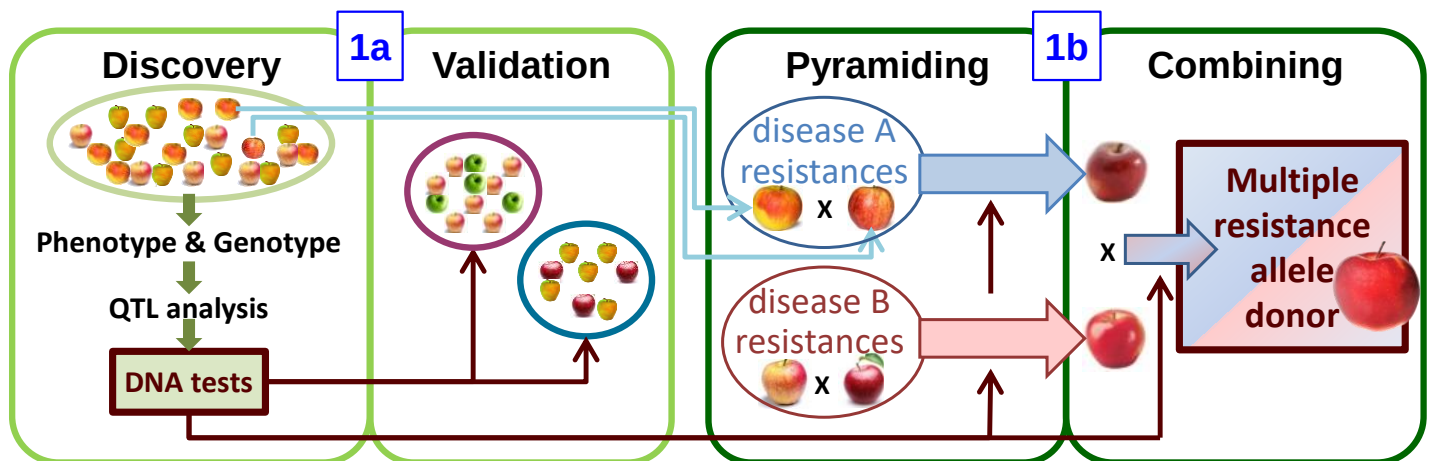
Blackberry: Fruit sweetness. This is the overwhelming need as there is not a major disease threat

- Univ. of Arkansas (Margaret Worthington)
- USDA-ARS Corvallis (Chad Finn)

OBJECTIVE 1

Incorporate Durable Disease Resistance in Breeding Parents

U.S. Rosaceae breeders, collaborating with pathologists, will identify and incorporate disease resistance alleles into breeding parents. Use of these parents will enable new disease resistant cultivars to be developed more rapidly, as these parents will donate multiple resistance alleles to their progeny.



Methods Overview: Participating teams of U.S. Rosaceae breeders and pathologists will:

1a Identify alleles and develop and validate DNA tests for disease resistance by QTL analysis

1b Incorporate these alleles by marker-assisted introgression into breeding parents, which we call “multiple resistance allele donors”. These multiple resistance allele donors, with pyramided resistance alleles from multiple sources for one disease and/or combined resistance alleles for multiple diseases, will be made available to breeders U.S.-wide.

Timeline: **1a** was initiated in Year 1 and will be completed at the end of Year 4. **1b** started in Year 1 for apple, Year 2 for peach, strawberry and tart cherry with resistance alleles pyramided or combined from at least two sources is to be completed by the end of Year 5.



Jay Norelli



Guido Schnabel

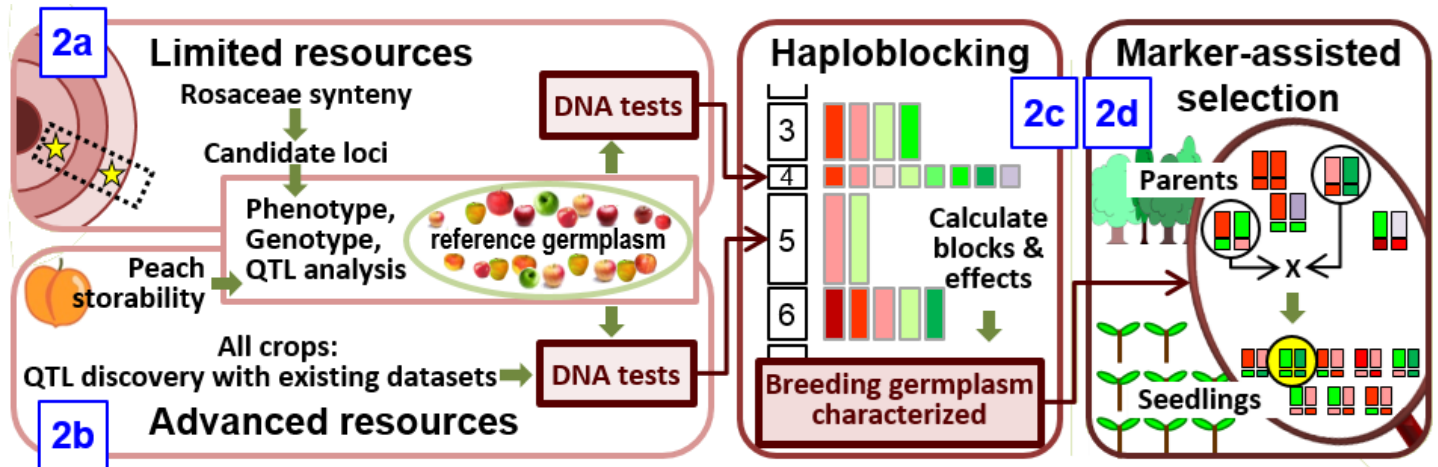


Kelly Ivors

OBJECTIVE 2

Combine Disease Resistance and Horticultural Quality

Development of cultivars that combine excellent horticultural quality and disease resistance will be enabled with knowledge of desirable alleles and their locations in the genome.



Methods Overview: New large-effect fruit quality alleles will be discovered by:

2a Leveraging syntenic genomic locations of QTLs, and

2b Using a genome-wide pedigree-based analytical approach,

2c Alleles within regions contributing to desired phenotypes will be identified by haplotype blocking (haploblocking) to expand selection decisions from individual loci and traits to many linked loci and traits.

2d Marker-assisted parent and seedling selection will combine disease resistance with superior horticultural quality in the next generation of breeding families.

Timeline: **2a–2c** was initiated in Year 1, with completion in Year 3. **2d** will be accomplished in Years 1-5 (apple, peach, strawberry, cherry) or Years 4-5 (rose, blackberry, pear).



Dorrie Main

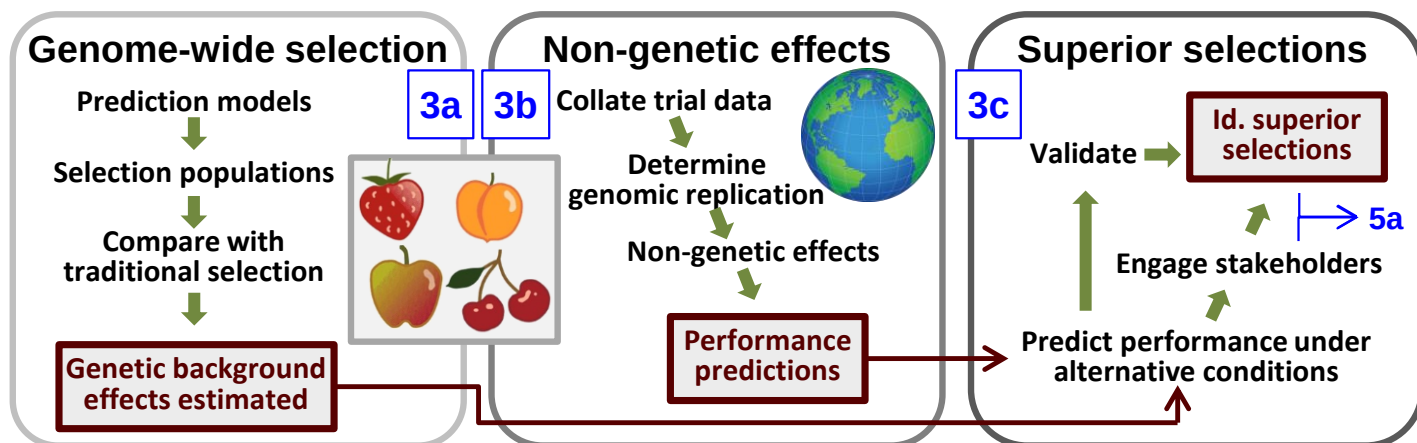
Carlos Crisosto

Amy Lawton-Rauh

OBJECTIVE 3

Advance Selections with Improved Confidence

New selections will be advanced toward commercial release with improved confidence due to more accurate predictions of fruit quality performance, which includes estimates of non-genetic factors (e.g., cultural practices, climate) and alleles at small-effect loci across the entire genome.



Methods Overview: Influences of genetic background and non-genetic factors will be identified using new statistical approaches to improve accuracy of predictions of genetic potential based on large-effect horticultural quality and disease resistance QTLs in apple, peach, sweet cherry, and strawberry breeding germplasm.

3a Genome-wide prediction models will calculate relative effects of genetic background (cumulative effects of individually small-effect alleles) using existing high-resolution phenotypic and genotypic datasets.

3b Genomic relationship matrices using dense SNP arrays will be used to merge RosBREED datasets with trials in the U.S. and other countries. Effects of non-genetic factors (e.g., management, climate, $G \times E$) will be evaluated to improve prediction accuracy of genetic potential among and within these factors.

3c In case studies, performance stability of elite selections under alternative growing conditions will be predicted using **3a** and **3b** results, validated, and used to streamline selection advancement and engage stakeholders in the latter stages of their breeding programs.

Timeline: **3a** and **3b** was initiated in Year 1 with data compilation and analysis completed in Year 4. **3c** will be conducted in Year 4.



Vance Whitaker



Rex Bernardo

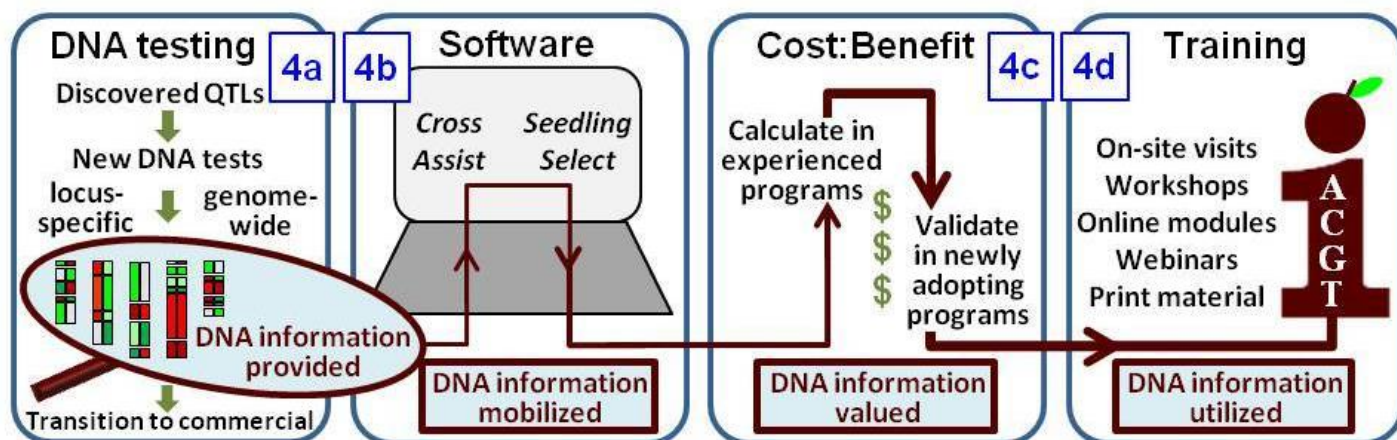


Craig Hardner

OBJECTIVE 4

Increase Routine Use of DNA Information

The development of cost-effective and accessible DNA diagnostic tools will enable DNA-informed breeding to be widely adopted by rosaceous crop breeders, leading to increased breeding efficiency.



Methods Overview:

4a Cutting-edge DNA diagnostic tools will be developed and crop-specific DNA testing services will be made available.

4b DNA Information will be integrated into enhanced decision support software.

4c Cost-benefit analyses will be conducted to identify tangible dollar values for DNA-informed breeding applications.

4d Breeders and allied scientists will receive technical training in use of DNA information in breeding.

Timeline: **4a** was initiated in Year 1 and tool development will continue until the end of Year 5. Routine DNA testing will transition to commercial service providers after Year 3. **4b** was discontinued in Year 3 due to sustained USDA mandated 7% budget cuts. **4c** cost: benefit analyses began in Year 1 and new adoption case studies will begin in Year 2; all will be completed in Year 4. **4d** technical training will be ongoing for all five years.



Nahla Bassil



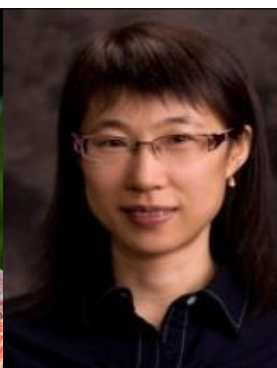
Chris Saski



Cameron Peace



Jim McFerson



Chengyan Yue



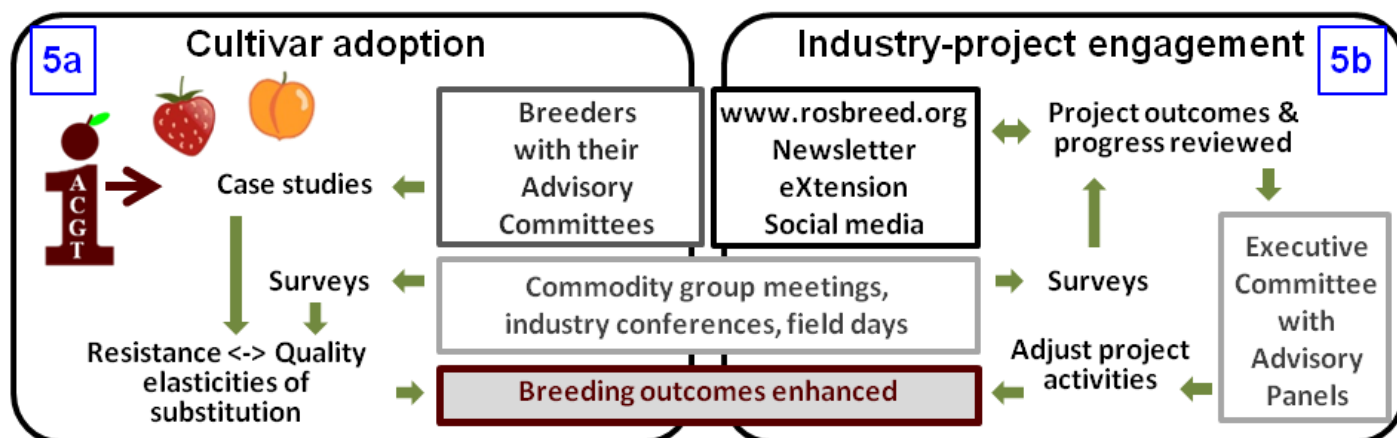
Vicki McCracken



Karina Gallardo

OBJECTIVE 5 Utilize Stakeholder Input

The impact of new cultivars will be maximized with industry stakeholder input into cultivar trait priorities and improved predictability of commercial performance. Due to the geographic and crop diversity within RosBREED, stakeholder input and recommendations will be specific for individual crop breeding programs.



Methods Overview:

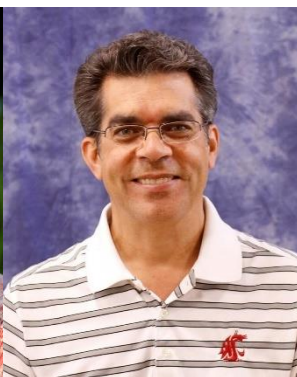
5a Stakeholder decisions on new cultivar adoption will be systematically investigated in two breeding programs.

5b Stakeholders are being engaged in project outcomes, evaluation, and adjustments.

Timeline: **5a** will be initiated in Year 2, with surveys conducted in Years 2 to 4. **5b** stakeholder activities will follow an annual timeline for all five years of recurring (and some ad hoc) meetings



Jim McFerson



Des Layne



Vance Whitaker



Lisa Wasko DeVetter



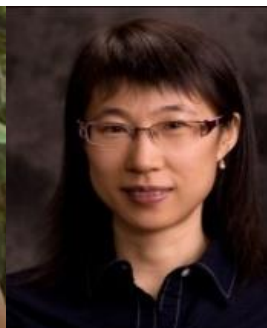
Greg Reighard



Vicki McCracken



Karina Gallardo



Chengyan Yue



Ksenija Gasic

Progress towards the use of DNA tests for diseases and physiological disorders

Table 1. Diseases and physiological disorders of apple, cherry, strawberry, peach, pear and rose where predictive DNA tests for major resistance loci are being sought. Stage of progress towards use of a DNA test is indicated.

Crop	Disease/Pathogen	Locus/Loci Discovered	Valuable Alleles Identified	DNA Test Developed (Test Name)	DNA Test in Use
Apple	Blue mold	<i>M. sieversii</i> PI	yes	Md-Pe3-SSR	yes
Apple	Foliar powdery mildew	<i>M. sieversii</i> (LG8)	yes	Md-Plw-SSR	yes
Apple	Scab	LG1	yes	CHVf1, VfSNP1, RviHC	yes
Peach	Bacterial spot - fruit	Clayton LG1 and LG6	yes	Ppe-Xap6	yes
Strawberry	<i>Phytophthora cactorum</i>	<i>FaRPe2</i> LG7D	yes	Pc2-HRM	yes
Strawberry	<i>Xanthomonas fragariae</i>	<i>FaRXf1</i> LG6D	yes	Xf1-HRM	yes
Sweet cherry	Powdery mildew – leaf and fruit	LG5	yes	Pav-G5PM-SSR	yes
Tart cherry	Cherry leaf spot	LG4	yes	SSR-CLS028	yes
Peach	Bacterial spot - fruit	LG1	yes	Ppe-Xap	in progress
Strawberry	<i>Colletotrichum gloeosporioides</i>	<i>FaRCg1</i> LG6B	yes	Cg1-HRM	in progress
Strawberry	<i>Colletotrichum acutatum</i>	<i>FaRCa1</i> LB6B	yes	Ca1-HRM	in progress
Apple	Scab	Honeycrisp (+Wildung) LG1 & HC LG15	yes	in progress	
Apple	Scab	Vh2, Wh4 and Vh8	yes	in progress	
Apple	Fire blight	Enterprise LG7 and LG 13	yes	in progress	
Apple	Soft scald/soggy breakdown	Honeycrisp LG2 & LG16	yes	in progress	
Apple	Zonal leaf chlorosis	Honeycrisp LG7	yes	in progress	
Pear	Fire blight	Moonglow, Roi Charles de Wurtemberg LG2	yes	in progress	
Apple	Fire blight	Splendour (three loci)	in progress		
Rose	Black spot	Brite Eyes™ (LG5-1)	in progress		
Pear	Fire blight (Old Home)	in progress			
Pear	Fire blight (Illinois 76)	in progress			
Peach	Fruit brown rot	in progress			
Peach	Bacterial spot – leaf	in progress			
Peach/Cherry	Armillaria root rot (plum, <i>P. maackii</i>)	in progress			
Rose	Black spot (Lemon Fizz, High Voltage)	in progress			
Tart cherry	Cherry leaf spot (sweet cherry, North Star)	in progress			
Strawberry	<i>Verticillium</i> (UNH germplasm)	in progress			
Strawberry	<i>Macrophomina phaseolina</i> (MI germplasm)	in progress			

Progress towards the use of DNA tests for maturity date and fruit quality traits

Table 2. Maturity date and fruit quality traits for which predictive DNA tests are available or being developed. Stage of progress towards use of a DNA test is indicated.

Crop	Trait	Locus/Loci Discovered	Valuable Alleles Identified	DNA Test Developed (Test Name)	DNA Test in Use
Apple	Fruit texture (ethylene)	<i>MdACS1</i> (LG15)	yes	Md-ACS1-indel, ACS1SNP1	yes
Apple	Fruit texture (ethylene)	<i>MdACO1</i> (LG10)	yes	Md-ACO1-indel, ACO1SNP1	yes
Apple	Fruit texture (firmness)	<i>MdPG1</i> (LG10)	yes	Md-PG1 _{SSR} 10Kd, PG1SNP1	yes
Apple	Fruit texture (firmness)	<i>MdExp7</i> (LG1)	yes	Md-Exp7-SSR	yes
Apple	Fruit texture (crispness)	<i>Ma</i> (LG16)	yes	Ma-indel, Ma1SNP1	yes
Apple	Fruit texture (acidity)	<i>Ma</i> (LG16 + LG8)	yes	Ma × A Acidity	yes
Apple	Fruit sweetness	<i>Md-LG1Fru</i> (LG1)	yes	Md-LG1Fru-SSR	yes
Apple	Bitter pit susceptibility	<i>Bp1</i> (LG16)	yes	BP16-indel	yes
Apple	Fruit skin blush	<i>Rf</i> (LG9)	yes	Md-Rf-SSR	yes
Apple	Fruit flesh color	<i>MYB110</i> (LG17)	yes	Md-S3-indel	yes
Peach	Fruit skin blush	<i>MYB10</i> (LG3)	yes	Ppe-Rf-SSR	yes
Peach	Fruit acidity/flavor	<i>D</i> (LG5) and <i>G7Flav</i> (LG7)	yes	Ppe-Acid	yes
Peach	Peach vs. nectarine	<i>G</i> (LG5)	yes	indelG	yes
Peach	Yellow vs. white flesh	<i>Y</i> (LG1)	yes	CCD4-SSR	yes
Peach	Fruit texture type	<i>F-M</i> and “ <i>SMF</i> ” (LG4)	yes	Ppe-Texture	yes
Peach	Maturity timing	<i>G4Mat</i> (LG4)	yes	G4Mat-SNP	yes
Strawberry	Fruity aroma	<i>FaFAD1</i> (LG3B)	yes	qFaFAD1	yes
Strawberry	Sherry aroma	<i>FaOMT</i> (LG7B)	yes	FaOMT-SI/NO	yes
Sweet Cherry	Fruit size & firmness	LG2	yes	Pav-G2-SSR	yes
Sweet Cherry	Fruit color type	LG3	yes	Pav-Rf-SSR	yes
Sweet Cherry	Fruit maturity time	LG4	yes	Pav-Fht-SSR	yes
Sweet Cherry	Fruit cracking	LG5	yes	Pav-G5Crack-SSR	yes
Tart Cherry	Fruit flesh color	LG3	yes	LG3_13.146	yes
Apple	Soft scald	LG2	yes	in progress	
Peach	Fruit size	LG4, LG6	in progress		
Strawberry	Fruit sweetness (SSC)	LG6A	in progress		
Sweet Cherry	Fruit sweetness	LG2	in progress		
Blackberry	Fruit sweetness (SSC)	in progress			
Peach	Postharvest fruit quality	in progress			
Tart Cherry	Fruit firmness	in progress			
Tart Cherry	Fruit freestone	in progress			

Progress towards the use of DNA tests for productivity traits

Table 3. Productivity traits for which predictive DNA tests are available or being developed. Stage of progress towards use of a DNA test is indicated.

Crop	Trait	Locus/Loci Discovered	Valuable Alleles Identified	DNA Test Developed (Test Name)	DNA Test in Use
Apple	Cross-compatibility	<i>S</i> locus (LG17)	yes	S-geno-SNP	yes
Strawberry	Perpetual flowering	<i>FaPFRU</i> (LG4A)	yes	Bx215	yes
Sweet Cherry	Self-fertility	<i>S</i> locus (LG6, S4' allele)	yes	Pav-S4-indel	yes
Sweet Cherry	Self-fertility	LG3 (Cristobalina source)	yes	EMPaS02b	yes
Sweet Cherry	Cross-compatibility	<i>S</i> locus (LG6)	yes	Pav-S-common	yes
Tart Cherry	Self-fertility	<i>S</i> locus (LG6)	yes	(various)	yes
Tart Cherry	Bloom timing	LG4	yes	in progress	
Peach	Bloom timing	LG3, LG4	in progress		

Table 1: Objective 1 – Deliverables for Year 3

Objective	Sub-Objective	Year 3 Accomplishments	To Whom	Impact
1 Incorporate Durable Disease Resistance in Breeding Parents	1a. Disease resistance allele discovery and validation	Disease phenotypic data - collected for 5539 individuals segregating for disease resistance	Crop Breeding Teams and Pathology Team	These plant materials and their phenotypic and genotypic data are resulting in discovery of loci associated with disease resistance and enable development of DNA tests for breeding application
		Genome-wide genetic data for apple, sweet cherry, peach, pear, and rose populations phenotyped for disease resistance – obtained, quality-checked, and provided for analysis	DNA-Informed Breeding Team	
		Major-effect locus discovery: 27 disease resistant major loci identified and validated in U.S. breeding germplasm since project began (Table 1, page 17). Newly discovered loci in Year 3 include rose black spot (LGS-1), sweet cherry fruit powdery mildew (LGS), and zonal leaf chlorosis disorder (from Honeycrisp) linked to fruit skin color locus		
		DNA test development: 8 DNA tests developed for resistance loci since project began (Table 1, page 17). New DNA tests developed in Year 3 include sweet cherry fruit powdery mildew and two strawberry diseases	DNA-Informed Breeding Team, DNA Testing Team, Crop Breeding Teams	
		New strawberry populations segregating for disease resistance chosen for locus discovery – generated: 4 populations segregating for resistance to Fusarium, Macrophomina, and Verticillium (1 UC Davis, 3 combining MI and OR parents with a wild accession resistance source) 1 pedigree-connected germplasm set (n=62) segregating for Verticillium resistant (NH)	Strawberry Breeding Team and Pathology Team	These progenies will provide individuals that breeders can use as parents to develop cultivars with more durable disease resistance due to the presence of resistance from multiple loci
		New Prunus rootstock germplasm to search for Armillaria resistance – obtained and phenotyping initiated (open-pollinated seed from 91 accessions in USDA-ARS Prunus germplasm collection)	Stone Fruit Breeding Team and Pathology Team	
		Offspring created from crosses to pyramid or combine disease resistance alleles – obtained: E.g., Strawberry at UF: 4000 offspring generated to combine resistances for anthracnose and Phytophthora crown rot, and anthracnose with bacterial angular leaf spot; and 420 offspring generated to pyramid scab resistances	Crop Breeding Teams	
		Genotyping to identify offspring with multiple resistance loci – initiated: - Strawberry resistances to Colletotrichum, Phytophthora, Xanthomonas and bacterial angular leaf spot - Apple resistances to scab and blue mold	Crop Breeding Teams and DNA-Informed Breeding Team	
	1b. Pyramid and combine disease resistance alleles			

Table 1: Objective 1 – Year 3 Challenges (blue) and Year 4 Planned Deliverables (purple)

Objective	Challenge	Plan for Tackling
1 Incorporate Durable Disease Resistance in Breeding Parents	Difficulty in mapping fire blight resistant loci from ‘Splendour’ likely due to epistatic gene action	Use alternative mapping approaches including FlexQTL
	Spring floral freeze damage limited ability to make crosses in peach to pyramid disease resistance alleles	Crosses planned for spring 2018
	Current test for ‘Moonglow’ sources of fire blight resistance in pear not predictive in a larger germplasm collection	Map resistance in pear and identify predictive markers

Objective	Sub-Objective	What	To Whom	Impact
1 Incorporate Durable Disease Resistance in Breeding Parents	1a. Disease resistance allele discovery and validation	Disease phenotypic data of plant materials for 2018 season – obtained [pear fire blight, apple scab, strawberry root and crown rots, <i>Armillaria</i>]	Crop Breeding Teams and Pathology Team	These plant materials and their phenotypic and genotypic data will continue to lead to discovery of loci associated with disease resistance and enable development of DNA tests for breeding application
		Genome scan data of disease-phenotyped families – obtained [strawberry, tart cherry, rose]	Crop Breeding Teams and DNA Testing Team	
		Pear fire blight genetic map from the fire blight populations for trait locus discovery and validation – constructed	Crop Postdocs	
		Large-effect trait locus discovery for diseases and sources where phenotyping and genotyping completed – discovered for 7 diseases and resistance sources (Table 1, page 17)	Crop Breeding Teams and Crop Postdocs	
		DNA tests – developed and deployed for 18 resistance loci (Table 1, page 17)	DNA-Informed Breeding Team	Use of these DNA tests will enable the pyramiding and combining of resistance alleles in new elite plant materials
	1b. Pyramid and combine disease resistance alleles	New offspring created from crosses to pyramid and combine disease resistance alleles – obtained for apple, peach, tart cherry, strawberry Families for pyramiding/combining genotyped with disease-resistance DNA tests to advance resistant individuals – ongoing [various crops and diseases]	Crop Breeding Teams and Crop Postdocs	These progenies will provide individuals that breeders can use as parents to develop cultivars with more durable disease resistance due to the presence of resistance from multiple loci

Table 2: Objective 2 – Deliverables for Year 3

Objective	Sub-Objective	What	To Whom	Impact
2 Combine Disease Resistance and Horticultural Quality	2a. Horticultural quality allele discovery and validation – RosMAP	Blackberry families phenotyped for fruit quality traits, including sweetness and individual sugars (OR: n=288; AR, n=288) – completed	Berry Fruit Breeding Team	RosMAP will provide a shortcut to identifying valuable trait loci by leveraging knowledge of common ancestral origin across rosaceous genera, demonstrated here by sweetness in blackberry
		Candidate sweetness genes identified using Rosaceae synteny – blackberry effective haplotype discovery in progress	DNA Testing Team	
	2b. Horticultural quality allele discovery and validation – advanced resources	Major loci for peach fruit quality after storage being sought from Advanced Peach Crop Reference Set; genotypic data obtained with updated 16K peach array – completed, compiled with postharvest phenotypic data (~ 1 billion data points)	DNA-Informed Breeding Team	Rosaceae breeders will have new trait loci to learn the allelic combinations of their parents and from which to request new DNA tests that could reveal trait-associated alleles in their seedling families
		Major locus discovery for valuable horticultural traits using existing data sets: 26 DNA tests for fruit quality and production traits put into application since start of project (Tables 2 & 3, pages 18-19). In Year 3 this includes loci for peach fruit size, strawberry and sweet cherry sweetness, and soft scald/soggy breakdown apple disorder	DNA-Informed Breeding Team	
		Pedigree-Based Analysis software support – provided (for use with diploid crops)	Crop Breeding Teams	
		Large-effect locus discovery for tetraploid crops with newly developed software – utilized for QTL discovery in tart cherry	Crop Breeding Teams	
	2c. Compile locus-specific DNA information across the genome	Diversity-based haplotype discovery and analysis for fruit quality and growth QTL hotspot around <i>Ma</i> locus in apple – ongoing	Crop Breeding, DNA-Informed Breeding, and DNA Testing Teams	Knowledge of allelic variation across the genome in discrete blocks will allow the characterization of alleles present in diverse breeding germplasm at a resolution that breeders can easily manage
		Pedigree-based haploblocks defined for fruit quality QTL hotspot on LG2 in sweet cherry – completed		
	2d. Conduct marker-assisted selection for combined traits	Marker-assisted parent and seedling selection according to RosBREED's three DNA Testing Portals' crop groups – completed, all 20 demonstration breeding programs used DNA information for breeding decisions	Crop Breeding Teams	Breeders will benefit from DNA information for parent and seedling selection. Information on parents will determine which DNA tests are suitable for use on families; information on greenhouse-grown families will identify optimal sets of seedlings for field-planting. Use will enhance breeding efficiency, accuracy, creativity, and pace
		Use and experiences of marker-assisted parent and seedling selection – tracked (see report pages 31-32)	Administration, DNA-Informed Breeding, and Extension Teams	

Table 2 cont.: Objective 2 – Challenges (blue) and Year 4 Planned Deliverables (purple)

Objective	Challenge	Plan for Tackling		
2 Combine Disease Resistance and Horticultural Quality	Polyploidy of blackberry genome complicates genotyping of candidate genes	Investigate use of PacBio for sequencing target capture libraries to facilitate haplotype identification		
	Largest-effect trait loci identified for soluble solids content in strawberry, but results are extremely dependent on environment	Investigate GxE		

Objective	Sub-Objective	What	To Whom	Impact
2 Combine Disease Resistance and Horticultural Quality	2a. Horticultural quality allele discovery and validation – RosMAP	Candidate loci for sweetness – tested in blackberry sweetness	DNA Testing Team, Berry Fruit Breeding Team	This case study for RosMAP candidate locus approach will determine how readily a less-genomics-resourced crop like blackberry can be fast-tracked to having trait-predictive DNA tests by leveraging shared ancestry and resources of other Rosaceae crops
	2b. Horticultural quality allele discovery and validation – advanced resources	New QTLs for peach postharvest fruit quality sought from use of Advanced Peach Crop Reference Set – large-effect loci identified and alleles characterized	DNA-Informed Breeding Team	Rosaceae breeders will have new trait loci to learn allelic combinations of their parents and from which to request new DNA tests that could reveal trait-associated alleles in their seedling families
		Valuable loci and alleles from RosBREED 1 data sets – identified using Pedigree-Based Analysis software (Tables 2 & 3 pages 18-19)	Crop Postdocs and Crop Breeding Teams	
		Pedigree-Based Analysis software instruction – provided	Crop Postdocs and Crop Breeding Teams	Knowledge of allelic variation across crop genomes in discrete blocks will allow the characterization of alleles present in diverse breeding germplasm at a resolution that breeders can easily manage
	2c. Compile locus-specific DNA information	Diversity based haplotype construction and characterization in apple – in progress Functional utility added to apple haploblocks – in progress	DNA-Informed Breeding and DNA Testing Teams	
	2d. Conduct marker-assisted selection for combined traits	Pedigree-based haplotype construction and utility analyses for LG4 QTL hotspot in cherry and peach – in progress Marker-assisted parent selection and marker-assisted seedling selection genotyping provided for apple, peach, cherry, and strawberry breeding programs – conducted Marker-assisted parent selection genotyping provided for rose, blackberry, and pear – conducted Use and experiences of marker-assisted parent selection and marker-assisted seedling selection – tracked	Crop Postdocs and Crop Breeding Teams Crop Breeding Teams Administration, DNA-Informed Breeding, and Extension Teams	Breeders will benefit from DNA information for parent and seedling selection. Information on parents will determine which DNA tests are suitable for use on families; information on greenhouse-grown families will identify optimal sets of seedlings for field-planting. Experiences will underlie new success stories of enhanced breeding efficiency, accuracy, creativity, and pace to share widely to the breeding, industry stakeholder, and allied scientist communities

Table 3: Objective 3 - Deliverables for Year 3 (green) and Challenges (blue)

Objective	Sub-Objective	What	To Whom	Impact
3 Advance Selections with Improved Confidence	3a. Add genetic background effects	Apple: Prediction model for genome-wide selection tested on five RB2 apple families for fruit texture components – completed; 5 related apple populations phenotyped to validate predictions Peach: Prediction model for genome-wide selection – phenotypic and genotypic data sets transferred to Statistical Genetics Team, analyses underway Strawberry: Genome-wide selection strategy for parent selection for five traits – validated across 4 breeding cycles and applied in U Florida program in 2 cycles <u>Strawberry</u> : Within-family seedling genome-wide selection experiment – designed, data collection in progress	Apple breeders and Statistical Genetics Team Peach breeders and Statistical Genetics Team Strawberry breeders and Statistical Genetics Team	Offspring will be selected and advanced with improved confidence based on knowledge of significant and non-significant loci influencing trait variation Adoption of genome-wide predictions for parent selection in strawberry has resulted in reduction of breeding cycle from three years to two years
	3b. Add non-genetic effects	Sweet cherry GxExM model for sweet cherry on cherry maturity date – completed, tested; Analysis on fruit size – initiated <u>Estimation of non-genetic effects for fruit sweetness from peach – initiated</u> <u>Estimation of non-genetic effects for fruit sweetness and acidity from apple – initiated</u> <u>Collation of multi-environment performance and SNP data sets for peach and apple – in progress</u>	Apple, peach, sweet cherry, and strawberry breeders and Statistical Genetics Team	Offspring will be selected and advanced with improved confidence based on knowledge of influence of non-genetic factors compared to genetic factors, including effects of climates/locations and management practices
Objective	Challenge	Plan for Tackling		
3 Advance Selections with Improved Confidence	Cost of high-density genotyping is too high for seedling genomic selection applications	Methods for reducing/imputing SNPs are being explored, with preliminary data indicating 1500 SNPs might be sufficient		
	Need to combine SNP data from three arrays (8K, 20K, and 480K)	Use a subset of sequenced individuals to establish a foundational database enabling pipeline to combine data sets		

Table 3 cont.: Objective 3 – Year 4 Planned Deliverables

Objective	Sub-Objective	What	To Whom	Impact
3 Advance Selections with Improved Confidence	3a. Add genetic background effects	<u>Apple</u> : Three genome-wide selection models (standard model, model fitting heterozygous SNP effects, model with large-effect QTLs as fixed effects) – developed and compared using five families	Pome Fruit Breeding Team and Statistical Genetics Team	Offspring will be selected and advanced with improved confidence based on knowledge of significant and non-significant loci influencing trait variation
		<u>Peach</u> : Prediction models – tested on training population; selection populations – genotyped and phenotyped	Stone Fruit Breeding Team and Statistical Genetics Team	
		<u>Strawberry</u> : Within-family seedling genome wide selection methods using low-density genotyping to reduce cost – evaluated	Strawberry Breeding Team and Statistical Genetics Team	
	3b. Add non-genetic effects	GxExM performance predictions – completed for sweetness and acidity in apple, sweetness in peach, and fruit size in sweet cherry	Statistical Genetics Team and internationally collaborating partners	Offspring will be selected and advanced with improved confidence based on knowledge of influence of non-genetic factors compared to genetic factors, including effects of climates/locales and management practices
	3c. Advance superior selections	Genotype advanced selections to predict performance – initiated	DNA Testing, Statistical Genetics, and Crop Breeding Teams	Selections will be advanced toward commercial release or discarded with improved confidence based on knowledge of significant and non-significant loci as well as non-genetic factors influencing trait variation

Table 4: Objective 4 Deliverables for Year 3

Objective	Sub-Objective	What	To Whom	Impact
4 Increase Routine Use of DNA Information	4a. DNA test and fingerprinting set development and germplasm screening services	DNA tests for new trait loci of disease resistances and fruit quality components – developed, adapted, converted, refined, or confirmed (currently 19+ tests are being used by rosaceous crop breeders) – for example, 2 new tests for peach blush and sweet cherry fruit powdery mildew resistance were developed in Year 3 (Tables 1, 2 & 3 pages 17-19)	Crop Breeding Teams and commercial service providers of DNA-based diagnostics	Demonstration breeders have access to DNA-based diagnostics services and specific tools; lessons learned for commercial providers
		DNA tests for multiple loci using a KASP mini-array – in development in peach, tests for 2 apple trait loci converted to KASP for seedling selection	Stone Fruit Breeding Team, DNA Testing Team	
		Genome-wide diagnostic tool for cherry – updated and commercialized with addition of +9000 more SNPs added to 6K Illumina® Infinium array	Cherry breeders	
		DNA-based diagnostic services for Obj. 1 and 2 – provided to breeders. Three DNA Testing Portals of Berry & Rose, Apple & Cherry, and Peach collectively genotyped ~25,000 individuals with another ~30,000 individuals genotyped in U Florida strawberry breeding program	Crop Breeding Teams	
	4b. Software support	Annual International Partner Meeting – held 14 Jan 2017. Included 12 international collaborating partners from 7 institutions in 6 countries – genome scan and DNA test needs coordinated	DNA Testing Team, allied scientists, Rosaceae breeders	Tools for upstream genetic research and practical breeding developed/advanced efficiently
		Cross Assist and Seedling Select software: Objective removed in Year 3 as consequence of sustained USDA mandated 7% budget cuts	na	
	4c. Economics of DNA information use	DNA Test Effects software: Mixed-model method in ASReml-R to calculate effects of DNA tests, genetic background, and environmental main effects (year, location) – completed	DNA-Informed Breeding Team	DNA tests used with greater confidence because of improved accuracy of predictions
		Templates to calculate breeding cost: benefit for wide range of DNA-informed breeding applications, via case studies on apple (U Minn) – completed, provided to breeders	U.S. Rosaceae breeders	Knowledge of relative costs and benefits of various uses of DNA information in breeding and experiences of new adopters will increase impact of DNA information use in breeding
		Calculations of economics of DNA use where benefit modeled is decrease in seedling number in field per cultivar release – completed on apple (U Minn)		
		Case studies of new adoption of DNA information use – completed (MSU peach, WSU strawberry), manuscript in progress		

Table 4: Objective 4 Deliverables for Year 3 cont. (green) and Challenges (blue)

Objective	Sub-Objective	What	To Whom	Impact
4 Increase Routine Use of DNA Information	4d. Technical training in routine use of DNA information in breeding	Online training resources via three new Community Breeder Articles including introduction of “Haplotype mosaics” – provided; “For Breeders” webpage – updated (www.rosbreed.org/breeding)	U.S. Rosaceae breeders and allied scientists	Rosaceae crop breeders benefit from use of DNA information to achieve greater efficiency, accuracy, and superior cultivar releases; knowledge of successes and limitations in DNA-informed breeding adoption identifies strategies and weaknesses to focus future efforts
		Compiled information on available DNA tests and information revealed – 4 new DNA test cards [2 sweet cherry, 1 apple, 1 strawberry] -> total 13		
		Assessment instrument to thoroughly assess breeding program opportunities, attitudes, status, challenges, and next steps in using DNA information – described (CB Page article Dec 2016), refined, used to facilitate training communications with U.S Rosaceae breeders		
		Annual update by External Evaluator on adoption of DNA-informed breeding by U.S. rosaceous crop breeders including pitfalls and limitations – provided (see report pages 31-32)	Administration, DNA-Informed Breeding, and Extension Teams	

Objective	Challenge	Plan for Tackling
4 Increase Routine Use of DNA Information	<i>Prunus</i> Crop Postdoc at Clemson U left unexpectedly	New Postdoc hired; MSU postdoc assists with tasks and training of the new Postdoc
	Time needed for “upstream research” tools and information (genome scan development, QTL discovery, DNA test development, etc.) greatly limits time available for Crop Postdocs to conduct their role of liaising with U.S. Rosaceae breeders	Genome scan work should be much less in Year 4; other project scientists help with communications with community breeders; Crop Postdocs focus on their identified research strengths

Table 4 cont.: Objective 4 Year 4 Planned Deliverables

Objective	Sub-Objective	What	To Whom	Impact
4 Increase Routine Use of DNA Information	4a. DNA test and fingerprinting set development and germplasm screening services	New DNA tests from discoveries in Obj. 1 and 2 – developed (see targets in Tables 1, 2 and 3, pages 17-19) Use of new haplotype framework to refine DNA tests and convert SNP array information for parents/elites into performance-relevant information – initiated	DNA Testing Team	Demonstration breeders have sustained access to DNA-based diagnostics services, specific tools, and information on their germplasm
		DNA testing services provided and transitioning to fee-based – almost complete	Crop Breeding Teams	
		Objective removed	Crop Breeding and DNA Testing Teams	
	4b. Software support		na	na
	4c. Economics of DNA information use	Cost: benefit case studies (U Minn apple) – analyses completed and communicated New adoption case studies (MSU peach, WSU strawberry) – analyses completed and communicated	U.S. Rosaceae breeders	Knowledge of relative costs and benefits of various uses of DNA information in breeding and experiences of new adopters will increase impact of DNA information use in breeding
	4d. Technical training in routine use of DNA information in breeding	Online resources: training modules in specific topics – developed and delivered via website of “For Breeders” (www.rosbreed.org/breeding) One-on-one communication continued, all U.S. breeders assessed for challenges and opportunities to their DNA-informed breeding adoption; common challenges and opportunities addressed in online content, idiosyncratic ones addressed according to cost:benefit and as resources allow [Arising from one-on-one communication above] Successful adoption of DNA-informed breeding by U.S. rosaceous crop breeders – quantified; Pitfalls and limitations – identified	U.S. Rosaceae breeders Administration, DNA-Informed Breeding, and Extension Teams	Rosaceae crop breeders benefit from use of DNA information to achieve greater efficiency, accuracy, and creativity culminating in superior cultivar release; knowledge of successes and limitations in DNA-informed breeding adoption identifies strategies and weaknesses to focus future efforts

Table 5: Objective 5 Deliverables for Year 3 (green) and Challenges (blue)

Objective	Sub-Objective	What	To Whom	Impact
5 Utilize Stakeholder Input	5a. Cultivar adoption case studies	Producer surveys for case studies of cultivar release – conducted for peach (33 respondents); in progress for strawberry, data analysis ongoing	U.S. peach and strawberry breeders	Insight into decision-making received from peach and strawberry industry members about new elite selections will inform cultivar development and release strategies
	5b. Stakeholder engagement	Year 2 Advisory Panel meeting (Jan 2017): communication of project activities, outcomes, impacts, challenges, receipt, and addressing of feedback – conducted	Advisory Panel members, Project participants, RB Exec Committee	RosBREED project increases effectiveness; external and internal stakeholders value project outcomes
		Update website and distribute Newsletter – accomplished	All stakeholders	Awareness of and support for RosBREED enhanced; DNA-informed breeding widely accepted by industry stakeholders;
		Project outcomes and impacts communicated through electronic media and presentations at industry meetings – conducted (numerous channels & venues)	Industry stakeholders	Extension AP members Dave Eddy and David Karp continue regular contributions to Newsletters and their wider circles of influence; robust data sets of stakeholder and breeder attitudes about DNA information used to adjust project activities
		Breeder engagement in Year 2 with stakeholders about DNA-informed breeding and stakeholder input – obtained and summarized (see report on pages 31-32)	RB Executive Committee, External Evaluator, Team Leaders	
		Proposal for major three-session symposium on SCRI (and highlighting RosBREED) at Amer Soc Hortic Sci ann mtg, Washington DC, July 2018 – developed, accepted		

Objective	Challenge	Plan for Tackling
5 Utilize Stakeholder Input	5a. Low survey response rate. Responses were mostly from operations <50 acres	Peach: complement mail survey responses with audience survey at SE peach growers meeting Strawberry: Online strawberry survey targeting FL producers garnered more responses, surveys planned for 5 grower meeting in PNW
	5b. Need additional personnel to capture success stories and put them in format for lay audiences	New PhD student with journalism/plant breeding and genetics background and a dual future career interest recruited to begin at MSU on March 1, 2018 and join Extension Team

Table 5 cont.: Objective 5 Year 4 Planned Deliverables

Objective	Sub-Objective	What	To Whom	Impact
5 Utilize Stakeholder Input	5a. Cultivar adoption case studies	Case studies of peach and strawberry cultivar release – Peach: Analysis of data collected via 2016 mail survey will be complemented with data collected at the SE peach growers meeting in Savannah, GA 12 Jan 2018. – Strawberry: Analysis of data collected via mail and online surveys in progress. Also collecting relevant information on research priorities at 5 regional strawberry grower meetings in WA and OR – Data analysis initiated	U.S. peach and strawberry breeders	Insight into decision-making received from peach and strawberry industry members about new elite selections; will inform cultivar development and release strategies; methodological approach and results provide insights for other breeding programs and crops
	5b. Stakeholder engagement	Year 4 Advisory Panel meeting (Jan 2018): communication of project activities, outcomes, impacts, challenges, receipt and addressing of feedback – conducted	Advisory Panel members, Project participants, RB Exec Committee	RosBREED project increases effectiveness; external and internal stakeholders value project outcomes; awareness of and support for RosBREED enhanced; DNA-informed breeding widely accepted by industry stakeholders; robust data sets of stakeholder and breeder attitudes about DNA information used to adjust project activities
		Project outcomes and impacts communicated through electronic media and presentations at industry meetings – conducted	Industry stakeholders	
		Jargon-free one-pagers of success stories using breeding program-specific language and consistent format – developed and distributed	Crop Breeding Teams	
		Breeder engagement in Year 4 with stakeholders about DNA-informed breeding and their stakeholder input – obtained and summarized	External Evaluator, RosBREED Executive Committee, Team Leaders	

RosBREED Demonstration Breeders Annual Reports for Year 3 (9/1/2016 – 8/31/2017)

Progress in DNA-Informed Breeding Summarized by Michael Coe, Cedar Lake Research Group LLC

Respondents: 16 breeders or breeder teams representing 20 rosaceous crop breeding programs

Breeder-Industry stakeholder engagement about DNA-informed breeding in Year 3

Status

- During project year three, 18 of 20 RosBREED breeding programs engaged their regional stakeholders in formal or informal communications about DNA-informed breeding practices or opportunities. Formal presentations or publications for growers and other industry stakeholders were reported by 16 of the programs. Eighteen of the 20 programs reported informal discussions with stakeholder groups or individuals, focused on DNA-informed breeding opportunities.
- Industry stakeholders continued to express interest in and support for application of DNA-informed selective breeding, with many focusing on current needs for improved disease and insect resistance. Stakeholders continued to raise questions about genetic engineering methods such as gene editing and how these differ from or relate to selective breeding programs that may use DNA tests to inform selection. In addition to requests for more information about applications, costs and timelines of DNA-informed methods, stakeholders provided specific recommendations for traits and crops that should be the focus of new DNA tests, including increased emphasis on pear and caneberries as well as specific disease resistance, phenology and taste/aroma traits.

Themes in Breeders' Recommendations about Stakeholder Engagement

- Existing RosBREED extension materials were viewed as useful, and more were requested: DNA test cards, RosBRIEFs, the RosBREED website, newsletter, and slide sets. Other suggestions: video animations to explain DNA informed breeding in practice; additional downloadable material on RosBREED “by the numbers” from the newsletter.
- Continued direct engagement with industry and breeders, including visits to breeding programs and outreach to specific stakeholder groups, is important. It would help to develop more non-technical articles, videos, slides, and shared “talking points” with an emphasis on topics of interest such as progress on disease resistance. Crop-specific and region-specific communication is important.



Addressing Breeders' Needs



RosBREED Breeders' Annual Report for Year 3 Cont.

Breeding program use of DNA information

Status

- All 20 programs reported some use of DNA information in the past year.
- Fourteen programs reported using DNA information in the past year for verifying or understanding germplasm identity, relatedness, or parentage; 12 programs reported using DNA information for parent selection or planning crosses; 8 programs reported using DNA for seedling selection or culling; 15 programs reported using DNA information in year three for upstream research and development of direct relevance to their breeding program.
- A new rating scale for was instituted this year, asking for a summary of program use of DNA information over time (not just during the past year). Each of four categories of use are rated on a 5-point scale from “never used” to “the program does this on an ongoing, routine basis and is involved in developing new tests or applications.”
- Thirteen of 20 demonstration programs were rated as using DNA information on a routine basis (RosBREED’s goal; levels 3 or 4 on the scale) for at least one DNA use category.

Breeders' Recommendations

- Further training and documentation/tutorials for use of FlexQTL and other software tools; more intuitive, efficient software for data management, visualization and analysis
- Expanded training for DNA-informed breeding more generally, including funding and commercialization issues
- Continued development of phenotyping tools (e.g. FieldBook), markers and DNA tests for trait loci of near-term value to specific breeding programs and crop groups; more information about available vendors, services and costs; lower costs for genome scans
- Increased synergy between programs, across crops and public/private sector programs

Action items developed based on Demonstration Breeders' reports

- Continue to develop complementary slides, brochures, handouts, and online materials that can be used separately or together, using similar style and content so as to reinforce each other and the RosBREED “brand.”
- Continue to identify and publicize crop-specific success stories about DNA-informed applications in the context of overall breeding program activities; do not oversell.
- Continue to identify and publicize non-crop-specific RosBREED 2 success stories, such as success stories about students and technical staff members from RosBREED 1 – where they are now, how they were affected by RosBREED experiences, and success stories about scientific accomplishments due to synergistic RosBREED 2-led activities.
- Continue outreach through the website, newsletter, events, conferences, interactions with stakeholders, etc.
- Respond to Demonstration Breeder recommendations and needs.

Discussion Questions for Break-out Session

Instructions: While in your crop group, please discuss the five questions below and summarize your answers for the reporting session (3:15 pm).

Genomics Research and Use of DNA Information by Breeding Programs

1. What are the key emerging opportunities for DNA-informed breeding that are arising from worldwide Rosaceae genomics research? Is RosBREED best utilizing the outcomes, expertise, and datasets of this worldwide research? How can we better synergize?
2. How can DNA information be effectively integrated into what are mostly traditional breeding programs within the timeframe of RosBREED 2?

Breeding-Industry Interface

3. What's new (or gaining in importance) in industry that breeders need to know about and that RosBREED can help address?
4. At this point, is RosBREED providing a satisfactory return on investment by USDA and industry stakeholders? If not, how do you suggest we adjust activities?

Project Outreach

5. Given that the primary extension audiences are U.S. Rosaceae breeding and industry stakeholders, how effectively are we using avenues to achieve the goals described in the other four discussion questions? How can these avenues be more effectively employed?
 - RosBREED website
 - Newsletter periodical
 - RosBRIEFs
 - Social media
 - Annual RosBREED Advisory Panel meetings
 - Professional meetings (Amer Soc Hort Sci, Natl Assoc Plant Breeders, Rosaceae Genomics Conf)
 - Commodity group meetings
 - Individual breeding program interactions with their industries and other breeders (page 31-32)
 - Others?