RosBREED’s approach to bridging the gap between genomics knowledge and breeding application.

Amy Iezzoni
Project Director & Tart Cherry Breeder
www.rosbreed.org
Our Dream

Ultra-crisp tasty apples
sweet juicy peaches
flavorful cherries
luscious strawberries

Consistent quality, available & affordable

Enjoyed by consumers, regularly

Sustainably produced throughout the U.S.
Our Vision

Integration of modern genomics tools with traditional breeding approaches will transform crop improvement in Rosaceae, significantly improving profitability and sustainability of U.S. rosaceous crop industries & contribute to the increased consumption and enjoyment of these fruit, nut and floral products.
Why now?
Apple, peach & diploid strawberry genome sequences are available!
RosBREED bridges this chasm in genomics resources and marker-assisted breeding, leading to more efficient development of new cultivars.
Rosaceous Crops Included in RosBREED

Five crops were selected for this initial project: apple, strawberry, peach and sweet & tart cherry.
IMPACT: Focus on fruit quality: Demand from consumers and processors for premium cultivars.
RosBREED Organization

Executive Committee
- Cameron Peace
- Nahla Bassil
- Gennaro Fazio
- Jim Luby
- Dorrie Main
- Jim McFerson
- Eric van de Weg
- Cholani Weebadde
- Chengyan Yue

Project Director
- Amy Iezzoni

Project Assistant

Breeding Team Leader
- Jim Luby

Genomics Team Leader
- Dorrie Main

Genotyping Team Leader
- Nahla Bassil

Pedigree-Based Analysis Team Leader
- Eric van de Weg

MAB Pipeline Team Leader
- Cameron Peace

BIMS Team Leader
- Gennaro Fazio

Apple
- Susan Brown
- Kate Evans
- Jim Luby

Strawberry
- Jim Hancock
- Chad Finn
- Tom Davis

Peach
- John Clark
- Dave Byrne
- Ksenija Gasic
- Tom Gradziel

Cherry
- Nnadozie Oraguzie
- Amy Iezzoni
RosBREEDs International Partners.

Plant Research Intl., NL
East Malling Research, UK
INRA - Bordeaux, Avignon & Angers
CRA-FRU Rome
Andres Bello University, Chile
ARC, SA
Plant & Food Research, NZ
MISSION STATEMENT

We will develop and apply marker-assisted breeding, based on improved knowledge of industry value and consumer preferences, to accelerate and increase the efficiency of rosaceous cultivar release and successful cultivar adoption.

Amy Iezzoni, Michigan State Univ
Cameron Peace, WA State Univ

4 yrs
$7.2M federal
$7.2M matching

This project is supported by the Specialty Crops Research Initiative of USDA’s National Institute of Food and Agriculture
# Overview of RosBREED deliverables

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Trait and Market Class Breeding Target Establishment

Use knowledge of trait values & preferences from producers, processors, & consumers to prioritize breeder targets so that new cultivars will be more quickly accepted and have an enhanced commercial and consumer impact.
Trait Impact: Focus on fruit quality

Target trait selection: utilize improved knowledge of industry value & consumer preferences.

Are red fleshed peaches & nectarines high priority breeding targets? Would this fruit type have value in the marketplace? What is the economic weight for this fruit color trait?

Photos courtesy of Dr. Byrne (nectarine & peach)
What trait is my next breeding target?

We like disease resistant apple trees!

We like firm tart cherries that pit well!

I like tasty strawberries!

RosBREED’s Socio-Economics Team will determine trait values

Breeder survey 2010

Producer survey Fall 2011/Winter 2012

Market Intermediary survey Fall 2010

Household data analysis 2010 Consumer survey 2012
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RosBREED Demonstration Breeding Programs

- Univ. of Minn
  - Jim Luby

- Cornell Univ.
  - Susan Brown

- Washington State Univ.
  - Kate Evans

- Univ. of Ca Davis
  - Tom Gradziel

- Clemson Univ.
  - Ksenija Gasic

- Texas A&M
  - Dave Byrne

- Univ. of Arkansas
  - John Clark

- Michigan State Univ.
  - Amy Iezzoni

- Michigan State Univ.
  - Jim Hancock

- Washington State Univ.
  - Nnadozie Oraguzie

- USDA-ARS, Corvallis
  - Chad Finn

- Univ. of New Hampshire
  - Tom Davis

Rosaceae
Plant Material

Develop crop sets that represent the parental allele diversity across multiple breeding programs.

Crop Reference Sets
Crop Reference Sets

- 480 individuals (cultivars, ancestors, founders, breeding selections and seedlings) that fruit in 2010-2012

- Genotyped genome-wide with SNP markers & phenotyped for fruit quality traits and other high-impact traits.

- Enable efficient validation and utility assessment of Marker-Locus-Trait associations

- Resource for common benefit
• 4 Breeding programs
  • Limited overlap of germplasm between market types

• 118 cultivars and selections

• 373 progeny in 23 crosses

• Up to 11 generations
Phenotyping of the Crop Reference Sets

• Standardized phenotyping protocols were developed.

• Phenotypic data for apple, peach, and cherry was taken in 2010.
Apple Standardized Phenotyping

- Firmness, Crispness
  - Instrumental, Sensory
- Sweetness, Acidity
  - Instrumental, Sensory
- Color, Appearance, Juiciness, Aroma
  - Sensory
- Cracking, Russet, Sunburn
- Maturity
- Fruit size
- Postharvest disorders
- Harvest date, Crop, Dropping

At harvest
Storage 10w+7d
Storage 20w+7d

5 fruit (reps) per evaluation
You can access these standardized phenotyping protocols by visiting our website:
Genotyping of the Crop Reference Sets

- Genotyping to validate the first sets of marker-trait associations is underway.

- DNAs for the genome-wide SNP genotyping have been extracted and are awaiting development of the genotyping platform.
Fast-Tracked Pipelining in 2010 for Fruit Quality

**Peach**
1. Texture: endoPG F-M locus
2. Flavor: sweetness & acidity QTL

**Cherry**
1. Fruit quality: fruit size and firmness QTL
2. Flavor: acidity QTL

**Apple**
1. Flavor and Texture: acidity, crispness, juiciness QTL
2. Texture: Firmness QTL

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RosBREED: Enabling marker-assisted breeding in Rosaceae

[Image of peach, cherry, and apple]
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Pedigree Based Analysis
QTL discovery and validation and estimation of breeding values.
Identity-By-Descent (IBD): FlexQTL™

Jonathan × Golden
231 237 221 235
125 121 121 0
232 230 232 222

Septer × Cox
231 221 219 219
125 121 127 121
232 232 230 230

Elise
221 219
121 121
232! 230

Elise: 219 descents from Cox
⇒ Identical By Descent
Elise: 221 descents from GD

RosBREED
Enabling marker-assisted breeding in Rosaceae

Wageningen UR
For quality of life

www.rosbreed.org
SNP Genotyping Platforms

Develop and utilize high throughput genotyping platforms in collaboration with a newly formed Illumina SNP consortium to implement a 9K Infinium chip for each of apple and peach and a 6K chip for cherry.
<table>
<thead>
<tr>
<th>Peach Cultivar</th>
<th>Read Count (M)</th>
<th>Genome Coverage</th>
<th>SNP Frequency</th>
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<tr>
<td>Admiral Dewey</td>
<td>2.4</td>
<td>0.9</td>
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<tr>
<td>Slappey</td>
<td>2.0</td>
<td>0.7</td>
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<tr>
<td>Babcock</td>
<td>3.2</td>
<td>1.2</td>
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<tr>
<td>Elberta</td>
<td>0.6</td>
<td>0.2</td>
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<tr>
<td>Carmen</td>
<td>1.7</td>
<td>0.6</td>
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<tr>
<td>Chinese Cling</td>
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<td>0.9</td>
<td>14</td>
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<tr>
<td>Mayflower</td>
<td>1.3</td>
<td>0.5</td>
<td>29</td>
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<tr>
<td>Bolinha</td>
<td>3.5</td>
<td>1.3</td>
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<tr>
<td>Yellow St. John</td>
<td>1.4</td>
<td>0.5</td>
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<tr>
<td>J.H. Hale</td>
<td>3.2</td>
<td>1.2</td>
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<tr>
<td>Rio Oso Gem</td>
<td>2.6</td>
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<td>Diamante</td>
<td>2.1</td>
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<td>Dixon</td>
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<td>Early Crawford</td>
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<td>Dr. Davis</td>
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<td>Okinawa</td>
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<tr>
<td>Nemaguard</td>
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20 accessions in 5 multiplexes generated
- 3.8 Gb
- 2.3 Gb aligned
- 0.9 x coverage, on average
Marker Assisted Breeding Pipeline

Put MAB into practice.
RosBREED's MARKER-ASSISTED BREEDING PIPELINE

1. Choose valuable, impactful targets
2. Choose efficient genetic screening technologies and service providers
3. Adapt reported genetic tests to local genetic screening approach
4. Validate genetic tests across crop
5. Assess utility of genetic tests for breeding germplasm
6. Inform parent selection and crossing
7. Identify efficient seedling selection schemes
8. Trial seedling selection schemes
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Marker-Assisted Breeding Outcomes

Four year project outcomes

- Increased genetic knowledge flow across taxonomic boundaries in the Rosaceae
- Implementation of MAB by breeding programs
- Increased gain in fruit quality per breeding cycle due to improved parent selection and improved mean progeny value

Long-term outcomes

- More rapid availability of new cultivars with genetically superior fruit quality
- Improved profitability and sustainability of US rosaceous fruit, nut, and floral crops with increased consumption and enjoyment
- Increased gain in fruit quality per breeding cycle due to improved parent selection and improved mean progeny value
What's next?

It's not too early to identify knowledge gaps and goals for a second project... and add collaborators.

Polyploidy?, High resolution phenotyping?
RosBREED Co-PDs

MSU
Amy Iezzoni (PD)
Jim Hancock
Dechun Wang
Cho Weebadde

Univ. of Minnesota
Jim Luby
Chengyan Yue

WSU
Cameron Peace
Dorrie Main
Kate Evans
Karina Gallardo
Raymond Jussaume
Vicki McCracken
Nnadozie Oraguzie
Mykel Taylor

Univ. of Arkansas
John Clark

Univ. of CA-Davis
Tom Gradziel
Carlos Crisostolo

Univ. of Minnesota
USDA
Nahla Bassil
Gennaro Fazio
Chad Finn

Texas A&M
Dave Byrne

Plant Research Intl, Netherlands
Eric van de Weg
Marco Bink

Cornell
Susan Brown
Kenong Xu

Clemson
Ksenija Gasic
Gregory Reighard

Univ. of New Hamp.
Tom Davis
International Project Participants

ARC    Jasper Rees

Dan Sargent

Herman Silva & Lee Meisel

INRA (Bordeaux, Angiers, Avignon)

David Chagné

Ignazio Verde

RosBREED
Enabling marker-assisted breeding in Rosaceae
Questions?