The **Rosaceae family** of horticultural crops

- **STONE FRUIT**
- **POME FRUIT**
- **BERRIES (some)**
- rose

**RosBREED**
RosBREED I - Agenda

• Day 1 - What is RosBREED?
  - Project overview
  - RosBREED demonstration breeding programs
  - Introduction to RosBREED activities (3 presentations)
    Activity 1: Socio-Economics
    Activities 2-4: Setting up & implementing the marker-assisted breeding pipeline
    Activity 5: Extension
  - External Extension Evaluation
  - Interactive Discussion with Advisory Panel Members
  - Dinner Buffet at the Marriott Courtyard: 6 PM
Socio-Economics Team interactions

Chengyan Yue
Karina Gallardo
Ray Jassaume
Vicky McCracken
Mykel Taylor

• Breeder interviews: Breeders' current trait selection practices

• Industry Stakeholders: Producer/processors' preferences and willingness to adopt new cultivars
RosBREED I - Agenda

- Day 2 - Team activities
  - Software demonstration and targets
  - Hands-on software session
  - Project web-based communication
  - Socio-Economic breeder interviews
  - DNA marker polymorphism discussion

Access to wireless internet available in the Windsor Room.
Password = rosbreed
Project Overview

Amy Iezzoni
Project Director & Tart Cherry Breeder
Imagine......

ultra-crisp tasty apples, sweet peaches that do not get mealy, flavorful cherries and strawberries, consistently available from your local grocery store.

These are the kinds of fruits that our RosBREED project can help develop using new genetics and genomics technologies.
Honeyscrisp: a breakthrough cultivar

- Honeyscrisp apple - introduced 1991 by the Univ of Minn.

- Dramatic attention and U.S. market share this decade.

- An ultra-crisp juicy texture and pleasing flavor

- Required 30 years from crossing to commercialization.
Disadvantages:
- Time consuming (3-20 yrs/generation)
- Large land areas needed for testing
- Field maintenance is expensive (equipment, labor, chemicals)
The power of marker-assisted breeding is to move selection from the field to the greenhouse.

- Only elite individuals are planted in the field for further evaluation.
- Plus, with genetic information, parents can be chosen based on robust knowledge of what traits they will transmit to their offspring.

We waited three years for fruit....

...and this genotype has extremely small fruit.

Large fruit

Small fruit
RosBREED Mission Statement

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

Why now?
Apple, peach & diploid strawberry genome sequences will be available in 2010
There are over 250 marker-trait associations known in rosaceous crops and just a handful are being used to inform breeding.

Marker = a specific DNA segment that identifies a certain gene or gene region of interest.

Examples of known marker-trait associations.

• DNA markers for the self-fertility alleles in cherry and almond
• DNA marker for the major ethylene gene influencing apple texture
THE CHASM

Marker-trait associations

MAB routine use

Genomics Research

Breeding Programs

Trait low priority
Different germplasm
Unknown functional alleles
Weak linkage
Unknown genetic action
Unknown environ. effects
Unknown linkage drag
No local genotyping
Not cost efficient
No training in MAB
RosBREED bridges this chasm

Genomics

Resources

Genomics

Research

Marker

assisted

breeding

Breeding

Programs

More efficient
development of new
cultivars
Required lots of:

IDEAS

PLANNING

STAKEHOLDER BUY-IN
RosBREED DEMONSTRATION BREEDING PROGRAMS

Rosaceae

- WSU
- U Minn
- Cornell U
- UC Davis
- Clemson U
- Texas A&M
- U Arkansas
- MSU
- UNH
- USDA-ARS Corvallis

Institutions involved in RosBREED breeding programs.
IMPACT: Focus on fruit quality: Demand from consumers and processors for premium cultivars.
NATIONAL IMPACT: Breeders working in all major U.S. production areas for apples, peaches, and cherries are RosBREED Co-PDs.
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

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

Genomics Team Leader:
Dorrie Main

Genotyping Team Leader:
Nahla Bassil

Socio-Economics Team Leader:
Chengyan Yue

MAB Pipeline Team Leader:
Cameron Peace

BIMS Team Leader:
Gennaro Fazio

Pedigree-Based Analysis Team Leader:
Eric van de Weg
RosBREED never sleeps!

Plant Research Intl., NL
East Malling Research, UK
INRA – Bordeaux, Avignon & Angers
Andres Bello University, Chile
University of the Western Cape, SA
Plant & Food Research, NZ
The Rosaceae family

STONE FRUIT

POME FRUIT

BERRIES (some)

rose

RosBREED
Why should we all work together?

RosBREED is rooted in our vision that the common ancestry of the diverse rosaceaous genera can be harnessed to leverage knowledge and resources across commodity boundaries.

Proof of concept: Red pigmentation in apple and cherry fruit.
The same major gene is believed to be responsible for red core & foliage in apple, and skin & flesh color in cherry.

Chagne et al. 2007. BMC Genomics 8:212
Why should we all work together?

Common challenges.

1. Heterozygosity
2. Polyploidy (4x and 8x)
3. Long generation time
Pedigrees of apple breeding populations
Why should we all work together?

Stakeholders and the USDA expect partnerships that leverage human resources and facilitate the seamless sharing of results.

RosBREED is the largest group funded within the USDA-SCRI program.

Thank you for your support along the way.
RosBREED OBJECTIVES

1) Use knowledge of trait values to enhance new cultivar adoption, enlarge market potential, and increase consumption.

2) Establish sustainable infrastructure for marker-assisted breeding (MAB).

3) Integrate breeding and genomics information.

4) Conduct MAB in demonstration breeding programs.

5) Enhance sustainability of cultivar development through stakeholder education.
Project Goals: Extension

- RosBREED demonstration breeders and project associates will be trained to optimize utilization of marker-assisted breeding (MAB) and knowledge of trait values.

- Successful adoption of MAB will be enhanced by cross-communication and cross-disciplinary collaboration with allied scientists.

- Stakeholders will appreciate how the use of genomics information can be harnessed to develop new varieties that meet market needs and consumer preferences.
# Year 1 Meetings and Workshops

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<tr>
<th>Timeline</th>
<th>Meeting</th>
<th>Location</th>
<th>Target Audience</th>
<th>Theme</th>
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<tr>
<td>YR 1</td>
<td>RosBREED I</td>
<td>San Diego, CA</td>
<td>RosBREED Participants, Advisory Panel Members, &amp; Collaborators</td>
<td>RosBREED Orientation &amp; Planning</td>
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<td>SNP Summit</td>
<td>Seattle, WA</td>
<td>RosBREED Genomics team participants &amp; Collaborators</td>
<td>Design genotyping platforms in coordination with international partners.</td>
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<td>ASHS Workshop</td>
<td>Palm Springs, CA</td>
<td>Community breeders &amp; local Advisory Panel Members</td>
<td>RosBREED Introduction to Rosaceous community crop breeders</td>
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**Participatory Workshops & Regional Workshops**

**Communication Platforms**

[www.rosbreed.org](http://www.rosbreed.org)
RosBREED Components At-A-Glance

1. Trait & Market Class Breeding Target Establishment
   - Available M-L-T Associations
     - Warehouse
   - Selection Target Identifier
   - Technology Portfolio

2. Genome Scans & Comparative Genomics
   - Genome Database Resources
   - Crop Reference & Breeding Pedigree Germplasm Databases
   - Cross Planning Tool
   - Seedling Selection Efficiency Tool

3. Pedigree-Based Breeding Information Management System
   - Available M-L-T Prioritization
     - Genetic Screening Efficiency
   - Improved Markers
   - Validation
   - Utility
   - MAPS Decisions
   - MASS Cost Efficiency & Logistics
   - MASS Trial Use
   - Seedling Efficiency Tool
   - Cross Planning Tool
   - Pedigree Information Management System

4. MAB Pipeline Implementation
   - Routine MAB
   - Seedling Efficiency Tool
   - Cross Planning Tool
   - Pedigree Information Management System

5. Extension Platform
   - Extension Platform
   - Routine MAB
   - Seedling Efficiency Tool
   - Cross Planning Tool
   - Pedigree Information Management System
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)
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.
Pedigree Based Analysis

Pedigree, trait, and genotypic information for six apple seedlings, identifying a marker-trait association for skin blush on apple chromosome 9.

- The colored box behind each cultivar/seedling gives a quantitative impression of the % of skin overcolor (blush) of apple fruit at harvest (light yellow = 0%, bright red 100%).

- The two chromosomes of each cultivar are represented by parallel rectangles, shown here for apple chromosome 9. The horizontal lines on each chromosome represent marker loci.

- The amount of a color on a horizontal line indicates the probability that the marker comes from a specific founder.

- A marker-trait association is identified at the bottom end of LG 9. Breeding lines that are likely to have only alleles of Golden Delicious (L) have low % overcolor (GaPi_06), those that have an allele of either the first chromosome of Delicious or Lady Williams (H) have a moderate level, and seedlings that have both these alleles have a high overcolor. Alleles at two other known loci cause variation from this general pattern (Golden Delicious).
MAB Pipeline Implementation

- Put MAB Pipeline into practice
- Demonstrate MAB with high-impact targets
- Achieve routine MAB by demonstration breeding programs
- Technology transfer to all interested U.S. Rosaceae breeders

→ Routine marker-assisted breeding for U.S. Rosaceae
Marker-trait validation

Allele mining

Parental selection

Cherry Breeding Program

Fruit size

Fruit color

Self-compatibility

Marker-trait associations

MAB

NRI
How will RosBREED help me breed cherry leaf spot resistant tart cherry cultivars?
RosBREED will generate knowledge of the genetic control of fruit size & enable the use of this information to more efficiently achieve the desired fruit size while retaining the CLS resistance.

We are identifying the genetic changes that are responsible for this increase in fruit size.

**Sweet cherry cultivar**

12 grams

**Wild forest cherry**

2 grams
In sweet cherry, 3 linkage group regions have been identified that contain genes that control fruit size.

- **LG2**: Pollen & egg types for LGs 2, 3, & 6
- **LG3**: Fruit Color
- **LG6**: Self Fertility
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
Evaluation of Extension Impact

Michael Coe

1. Breeders & Allied Scientists (2010: baseline survey and interviews)

2. Producers/Processors, Marketing Groups, Trade Organizations (2010: baseline survey)

3. Graduate Students (baseline survey at beginning of traineeship)
RosBREED Extension Advisory Panel

Jessica Goldberger
Peter Hirst
David Karp
Mercy Olmstead
Ron Perry
Clark Seavert
Jamie Sherman
Brian Sparks
Chris Watkins
RosBREED Scientific Advisory Panel

Bert Abbott
Pere Arús
Joe Arvai
Fred Bliss
Robin Buell
Lailiang Cheng
Sue Gardiner
Carolyn Ross
Phil Simon
# Specialty Crop Research Initiative

## RosBREED Co-PDs

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<tr>
<th>MSU</th>
<th>Cornell</th>
<th>Univ. of Minnesota</th>
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<td>Amy Iezzoni (PD)</td>
<td>Susan Brown</td>
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<td>Tom Gradziel</td>
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<td>Marco Bink</td>
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International Project Participants

Jasper Reese
Dan Sargent
Herman Silva & Lee Meisel
INRA Group: Elisabeth Dirlewanger
David Chagné

RosBREED
Project Associates

Riaz Ahmad    John McQueen
Matt Clark    Lise Mahoney
Daniel Edge-Garza    Travis Stegmeier
Paul Sandefur    Steven McKay

Collaborators

Hans Jansen    Amit Dhingra
Chris Maliepaard    Bryon Sosinski
Roeland Voorrips    Vladimir Schulaev
Riccardo Velasco
Questions?