

UNIVERSITY OF CALIFORNIA STRAWBERRY
BREEDING PROGRAM

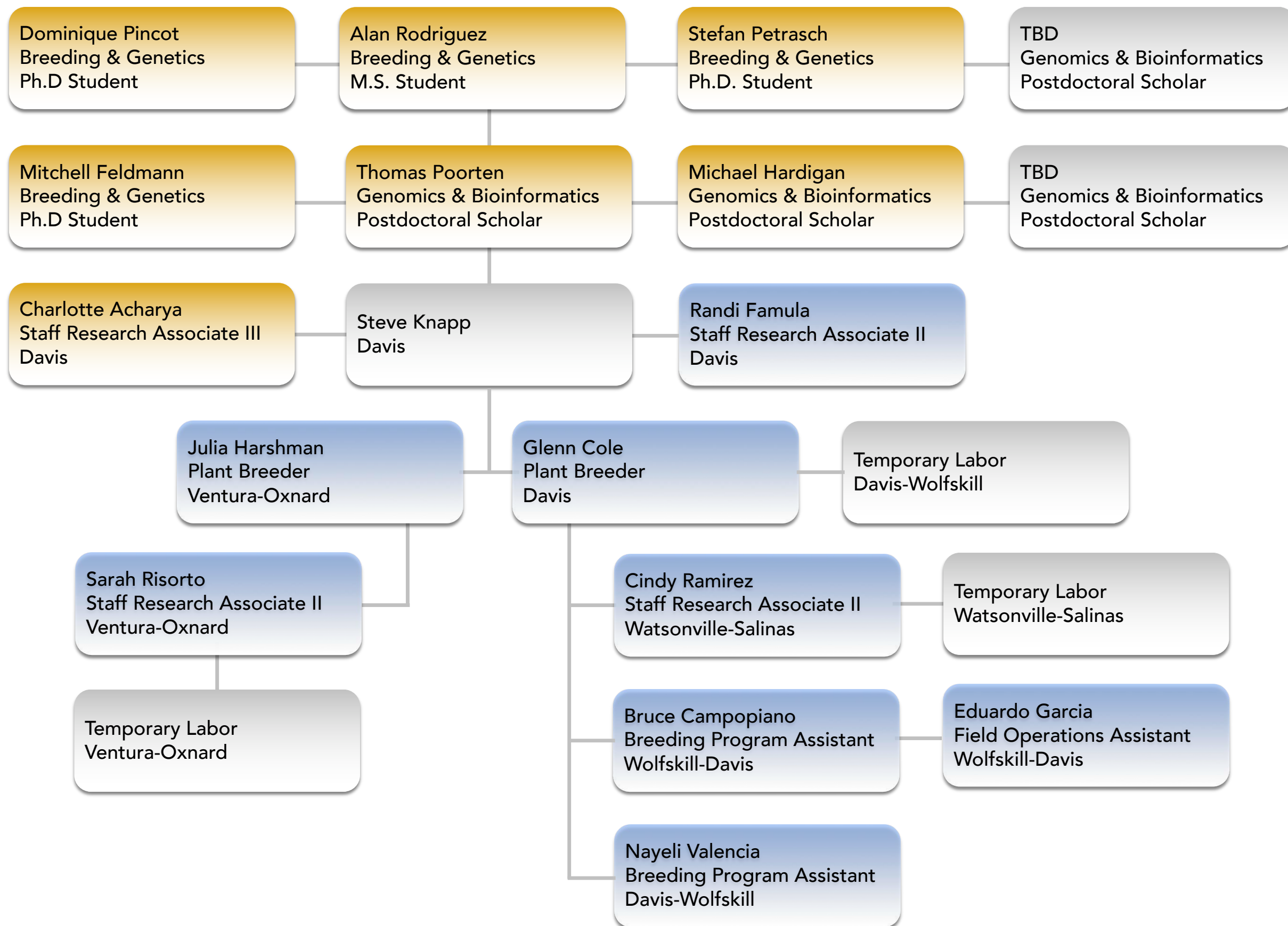
2017-2018 UPDATE AND PROGRESS REPORT



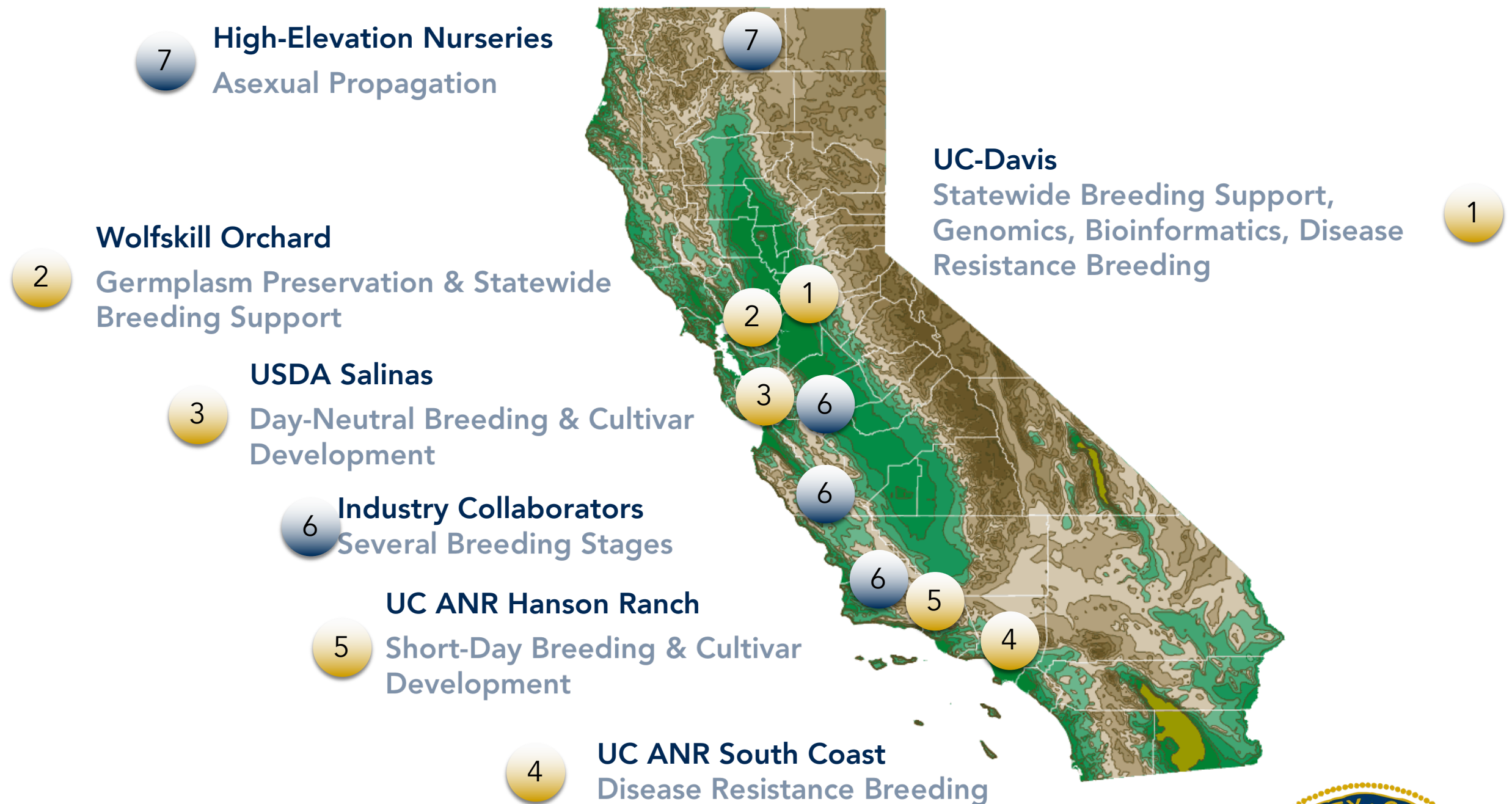
OVERVIEW

- Personnel & Infrastructure
- Germplasm Preservation, Protection, Documentation
- Cultivar Testing: Current and Future Releases
- Short-Day and Day-Neutral Breeding Pipelines
- Disease Resistance Initiative
- Genomics and Bioinformatics Initiative
- Consumer and Health Benefits Initiative





UCD Public Strawberry Breeding Program Operations



UC STRAWBERRY GERMPLASM COLLECTION

PRESERVATION, PROTECTION, DOCUMENTATION



UC STRAWBERRY GERMPLASM COLLECTION

1,700 ACCESSIONS MULTIPLIED @
LOW-ELEVATION (WOLFSKILL) IN 2017



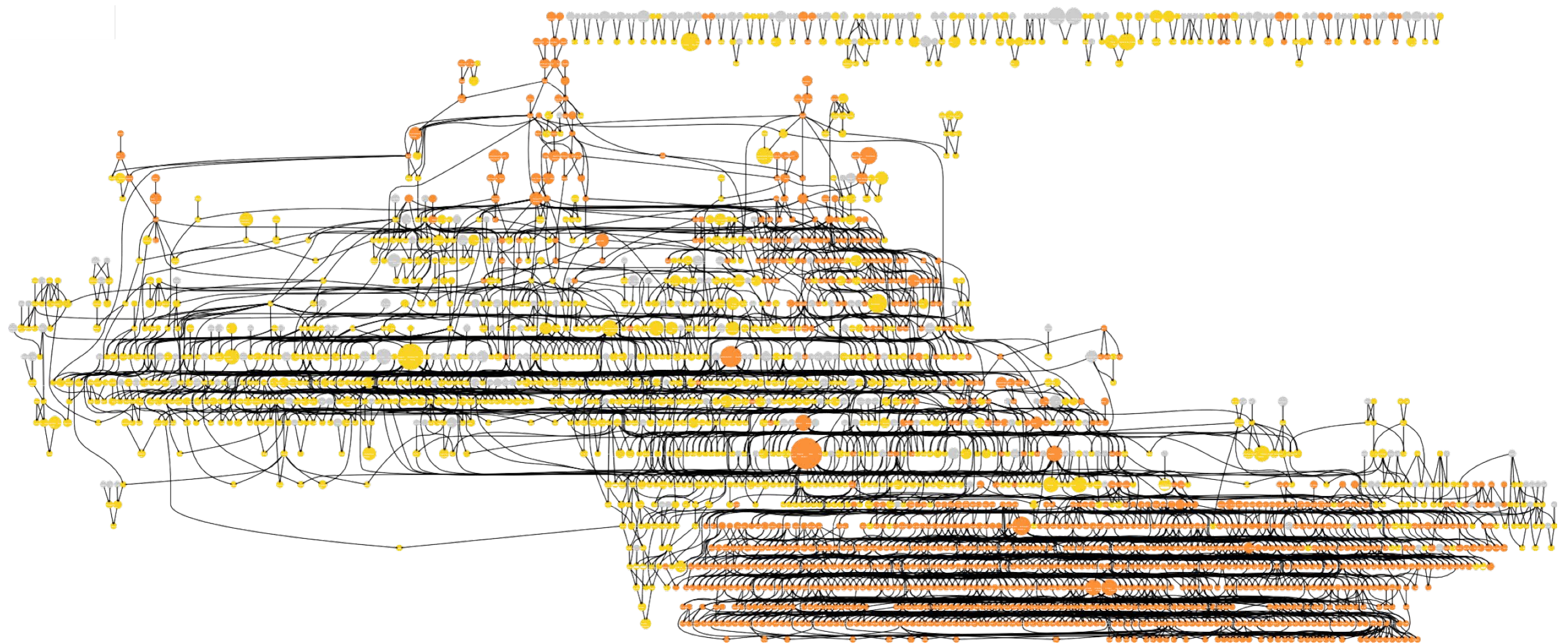
UC STRAWBERRY GERMPLASM COLLECTION

1270 ACCESSIONS MULTIPLIED @ HIGH-
ELEVATION IN 2017



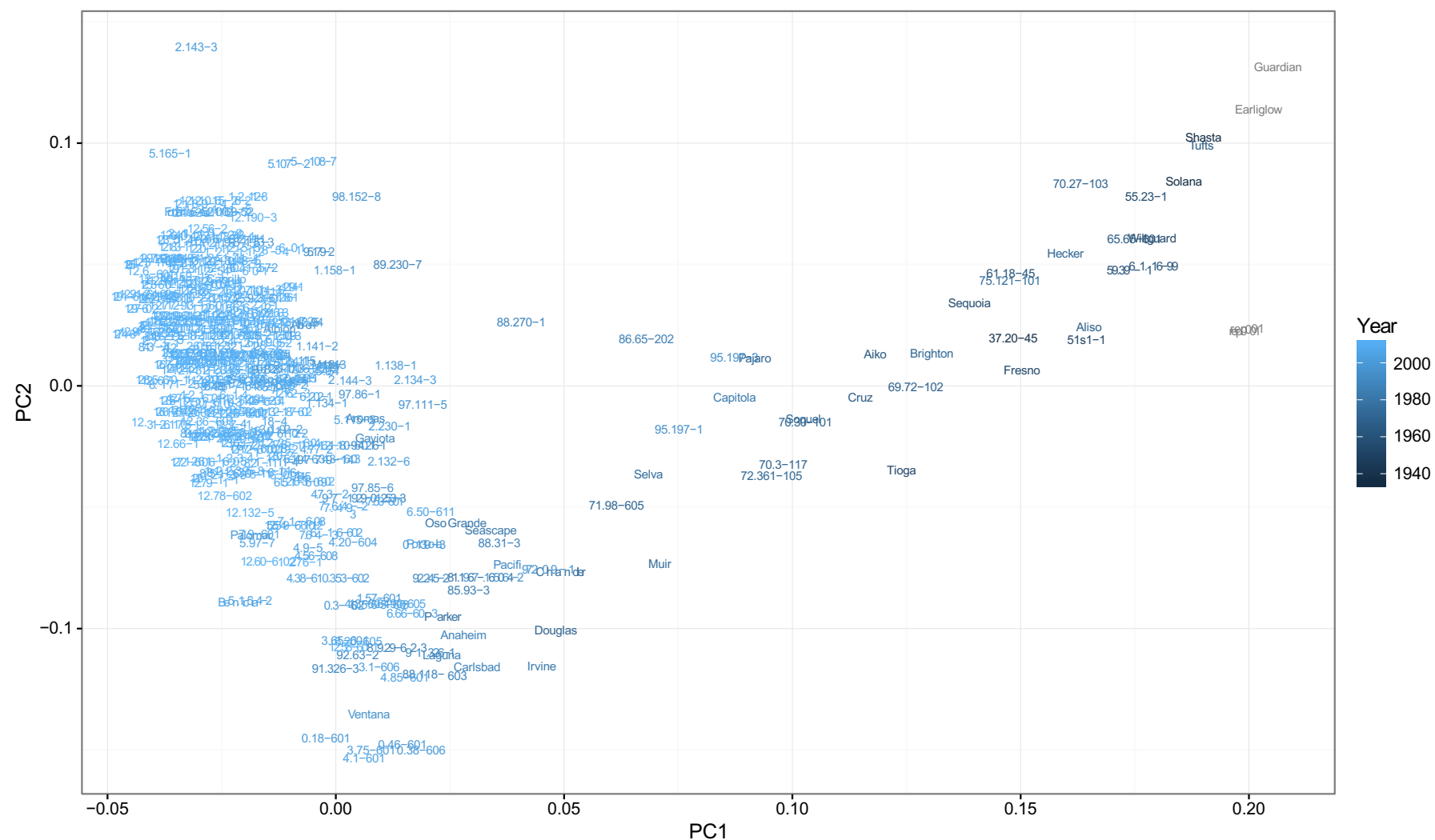
Strawberry Pedigree Database

- 2,296 Germplasm Accessions—Every Public Pedigree Since 1700
- UC Core Collection: 1,287 Accessions
- Small Number of Founders: < 20 Individuals Dominate Ancestry



DNA Fingerprint Database: Every Cultivar Has a *Unique* DNA Fingerprint

- UC and USDA Germplasm Collections ($n = 1,728$)
 - Affymetrix Axiom Array Interrogates 38,000 Single Nucleotide Polymorphism (SNPs) Dispersed Across the Strawberry Genome
 - 65.7 Million Molecular Datapoints (MDPs) = 38,000 MDPs/Accession x 1,728 Accessions



CULTIVAR TESTING, SELECTION, ADVANCEMENT, RELEASE
8 RELEASED AND 101 EXPERIMENTAL
CULTIVARS (UNRELEASED) TESTED IN 2016-2017



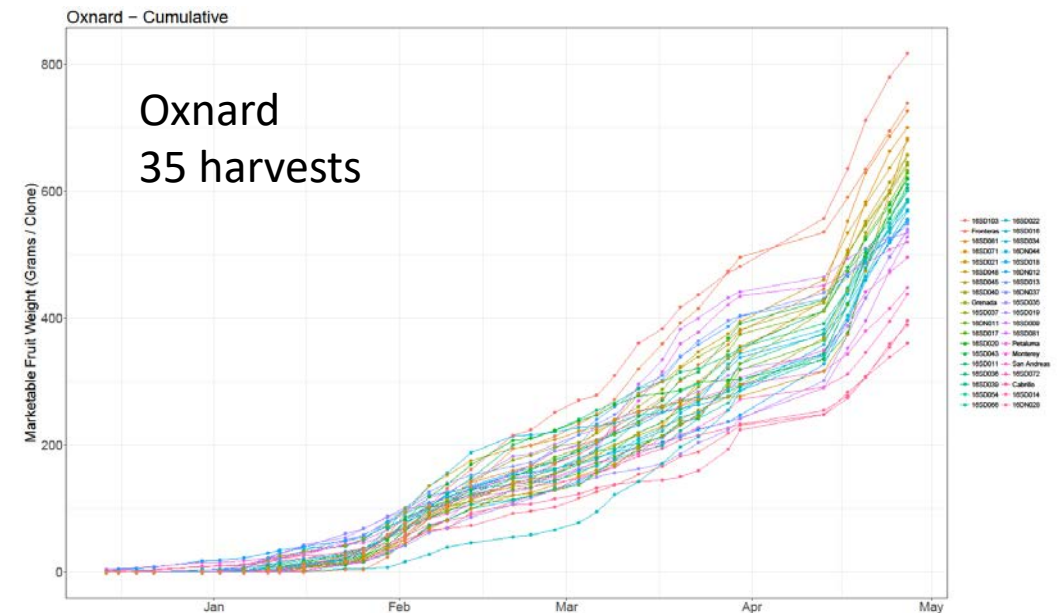
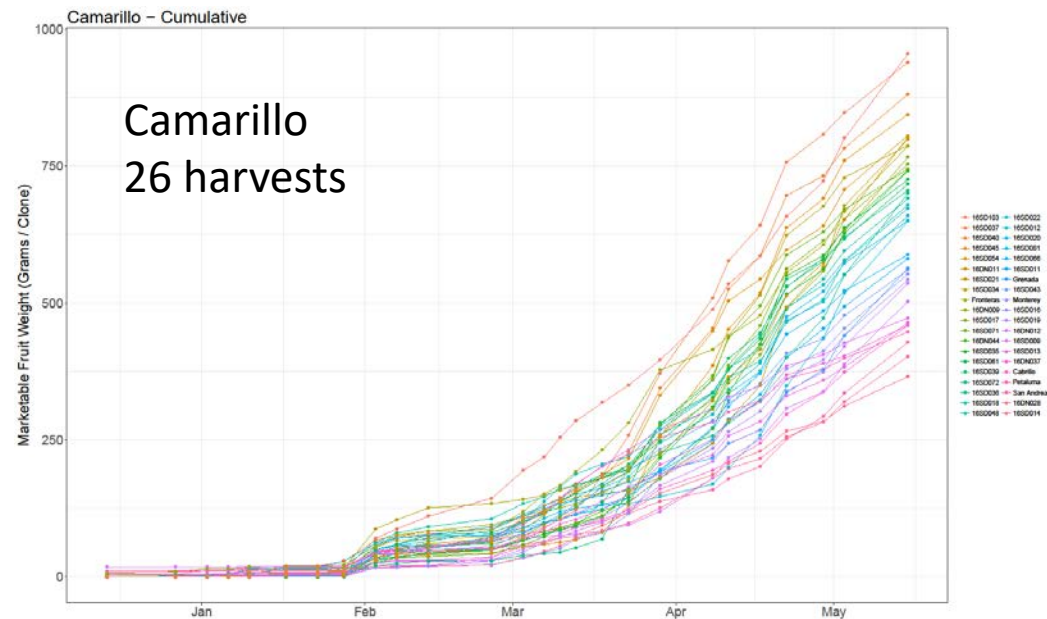
OXNARD AND SANTA MARIA, CALIFORNIA

2016-2017 SHORT-DAY CULTIVAR YIELD TRIALS



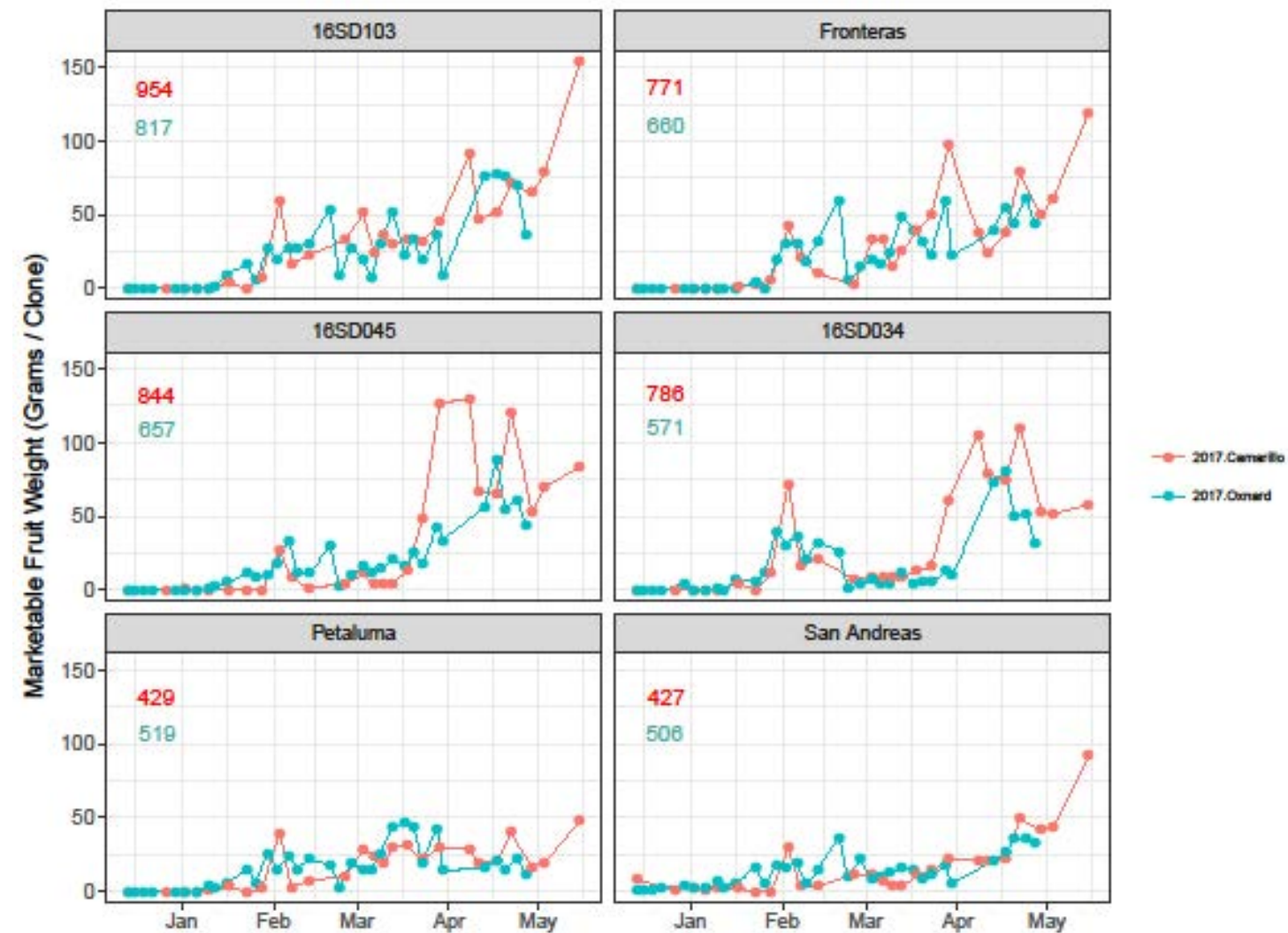
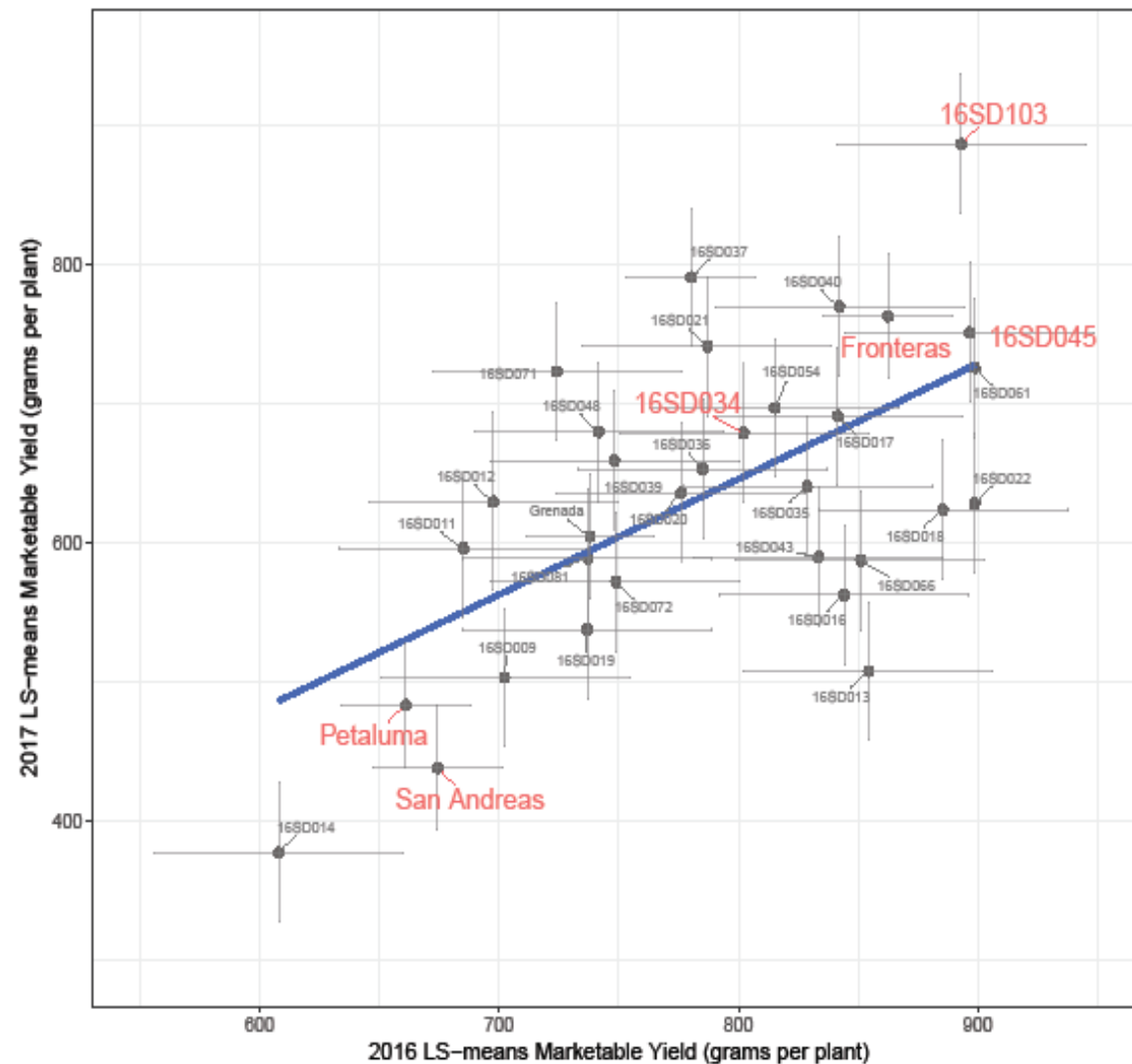
2016-2017 Short-Day Cultivar Testing: Cumulative Marketable Yield Over the Growing Season

35 New (Experimental, Unreleased) Cultivars + 6 Commercial (Released) Cultivars



- ▶ 3 Out of 35 (8.5%) Experimental Cultivars Selected for Precommercial Strip Testing on 8 Commercial Farms in 2017-2018
- ▶ Breeders Stock of 3 Short-Day Experimental Cultivars Submitted to UC Foundation Plant Services (FPS) for Clean Plant Multiplication and Potential Commercial Advancement in 2017-2018

Marketable Yield for Short-Day Cultivars Across Locations: Screen, Select, Advance



Anticipate Advancing 1-2 New
Short-Day Cultivars in 2018

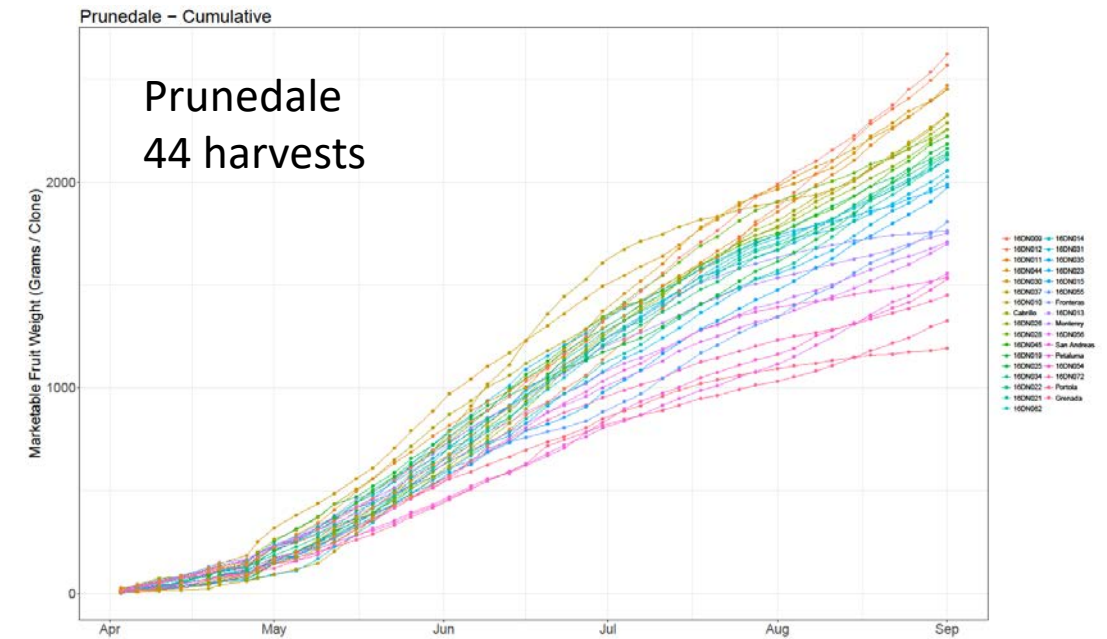
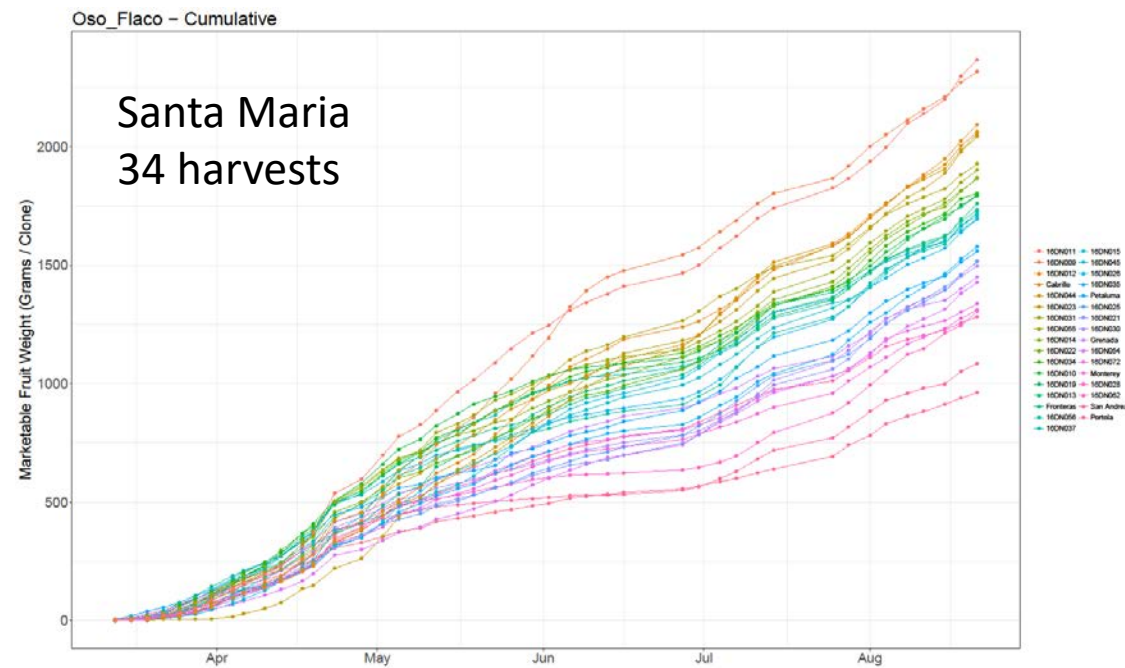
SANTA MARIA, PRUNEDALE, & WATSONVILLE, CALIFORNIA

DAY-NEUTRAL CULTIVAR TESTING AND ADVANCEMENT



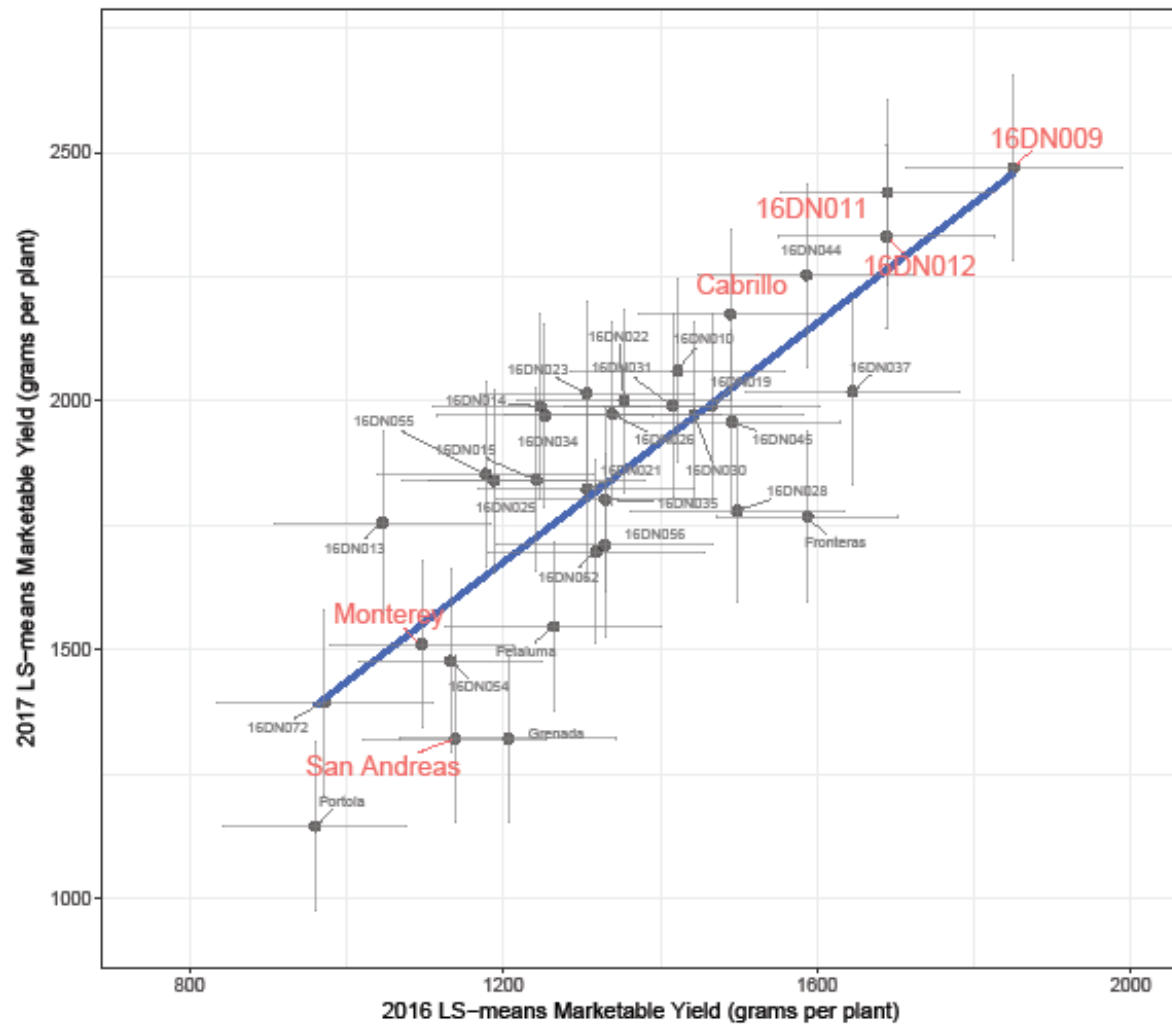
2016-2017 Day Neutral Cultivar Testing: Cumulative Marketable Yield Over the Growing Season

33 New (Experimental, Unreleased) Cultivars + 7 Commercial (Released) Cultivars



- ▶ 3 Out of 33 (9%) Experimental Cultivars Selected for Precommercial StripTesting on 8 Commercial Farms in 2017-2018
- ▶ Breeders Stock of 3 Day-Neutral Experimental Cultivars Submitted to UC Foundation Plant Services (FPS) for Clean Plant Multiplication and Potential Commercial Advancement in 2017-2018

Marketable Yield for Day Neutral Cultivars Across Locations: Screen, Select, Advance



Anticipate Advancing 1-2 New
Day Neutral Cultivars in 2018

NEW SHORT-DAY AND DAY-NEUTRAL BREEDING PIPELINES
SUSTAINED EXCELLENCE IN CULTIVAR
DEVELOPMENT



SHORT-DAY BREEDING AND CULTIVAR DEVELOPMENT PROGRAM
UC ANR HANSEN RANCH



DAY NEUTRAL BREEDING AND CULTIVAR DEVELOPMENT PROGRAM
UC DAVIS WOLFSKILL FARM



STRAWBERRY GENOMICS AND BIOINFORMATICS
DISCOVERY, INNOVATION,
APPLICATION



GENETICS OF ECONOMICALLY IMPORTANT TRAITS
IMPACTS TRADITIONAL AND
GENOMICS-ENABLED BREEDING

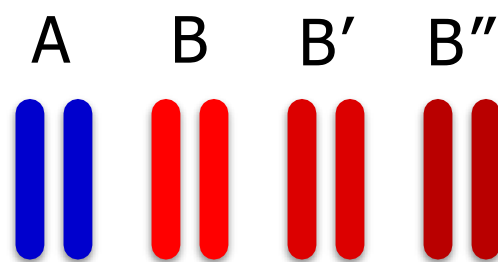


SIGNIFICANT BREAKTHROUGHS ON THE HORIZON

GENOMIC RESOURCES ARE RAPIDLY EXPANDING FOR OCTOPOLOID STRAWBERRY

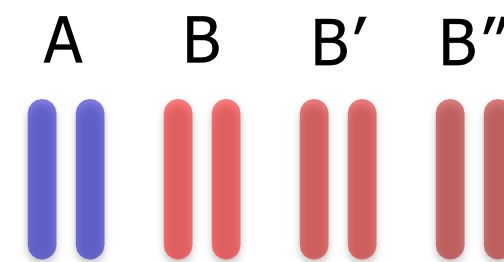
Fragaria chiloensis

$$2n = 8x = 56$$



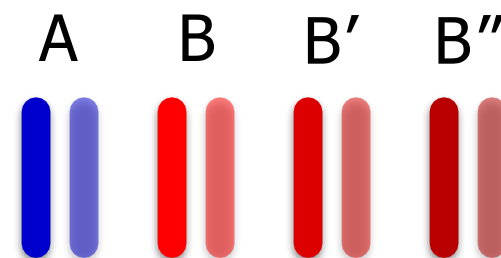
Fragaria virginiana

$$2n = 8x = 56$$

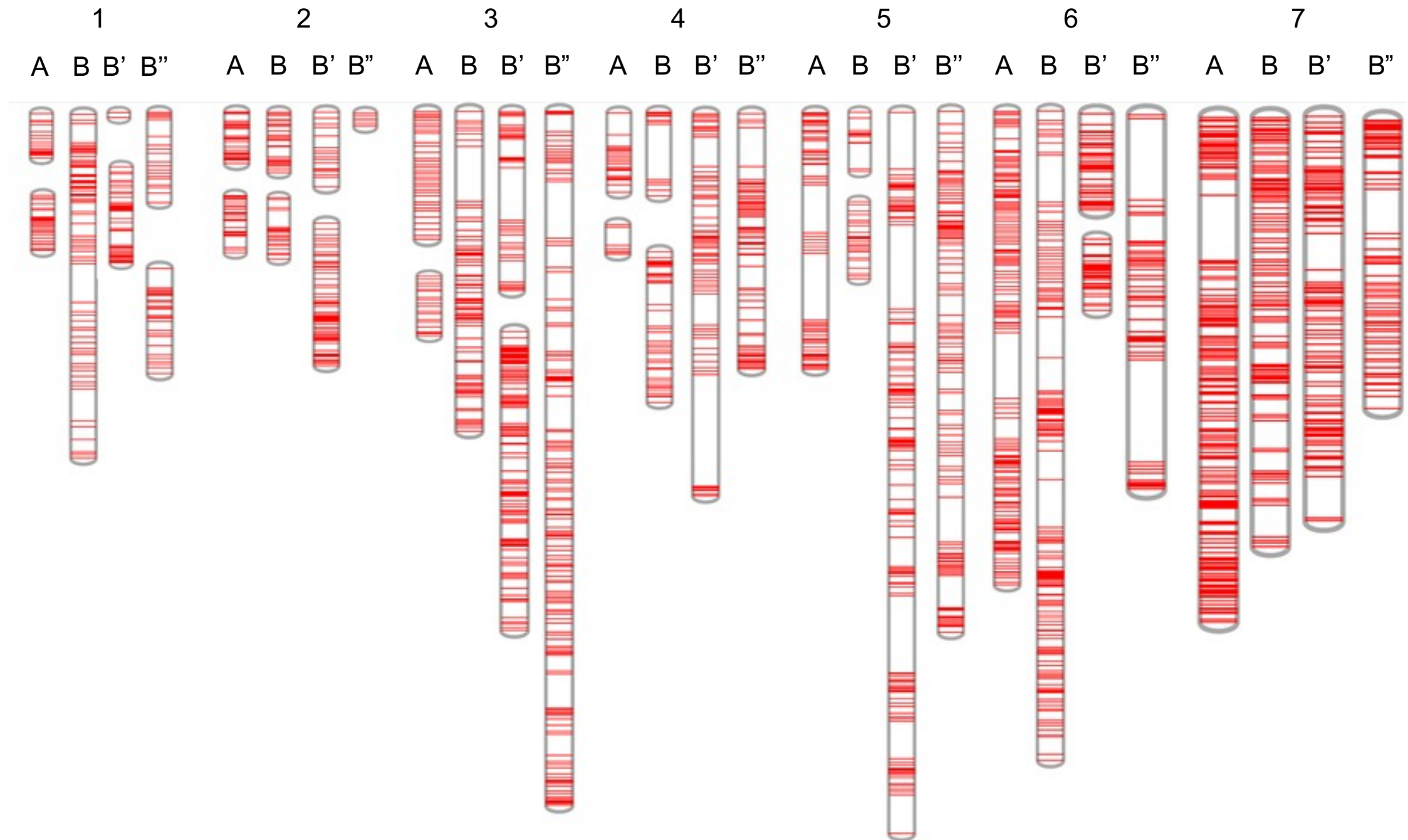


Fragaria × *ananassa*

$$2n = 8x = 56$$



Genetic Mapping in Octoploid Strawberry (Rousseau-Gueutin et al. 2008; Tennessen et al. 2014; Sánchez-Sevilla et al. 2015)



*Mapping Results Courtesy of Vance Whittaker and Sujeet Verma @ University of Florida—Approximately 18,000 Mapped SNP Loci

Genomics-Enabled Breeding

- ▶ 30,000+ Genes in the Strawberry Genome
- ▶ Upwards of 10 ‘Large Effect’ Genes Warrant Targeting for MAS
- ▶ MAS for a Small Subset Can Significantly Impact Genetic Gain
- ▶ Driving Allele Frequencies for Even 10 Loci to Fixation Across Diverse Germplasm is Challenging Nonetheless

Feature	Marker-Assisted Selection (MAS)	Genomic Selection (GNS)
Genetics	Simple	Complex
Heritability	High	Low to Moderate
Discovered Loci	Sufficient to Deliver Trait	Insufficient to Deliver Trait
Discovered Alleles	Large Effect and Highly Predictive	Small Effect and Irrelevant
Missing Heritability	Zero or Negligible	Moderate to Substantial
Impact	Supplant Phenotypic Selection	Speed, Scale, or Combination Thereof

DISEASE & PATHOGEN	MAS	GNS	RANK
Fusarium Wilt (<i>Fusarium oxysporum</i>)	×		1
Verticillium Wilt (<i>Verticillium dahliae</i>)	U	U	1
Charcoal Rot (<i>Macrophomina phaseolina</i>)		×	1
Anthracnose (<i>Colletotrichum acutatum</i>)	×		1
Red Stele (<i>Phytophthora fragariae</i>)	×		2
Angular Leaf Spot (<i>Xanthamona fragariae</i>)	×		3
Anthracnose (<i>Colletotrichum gleosporioides</i>)	×		4
Anthracnose (<i>Colletotrichum fragariae</i>)	U	U	5

DISEASE RESISTANCE BREEDING AND GENETICS

SOIL-BORNE PATHOGENS: *FUSARIUM*, *VERTICILLIUM*, *MACROPHOMINA*





DISEASE RESISTANCE BREEDING AND GENETICS

COLLECTOTRICHUM ACUTATUM

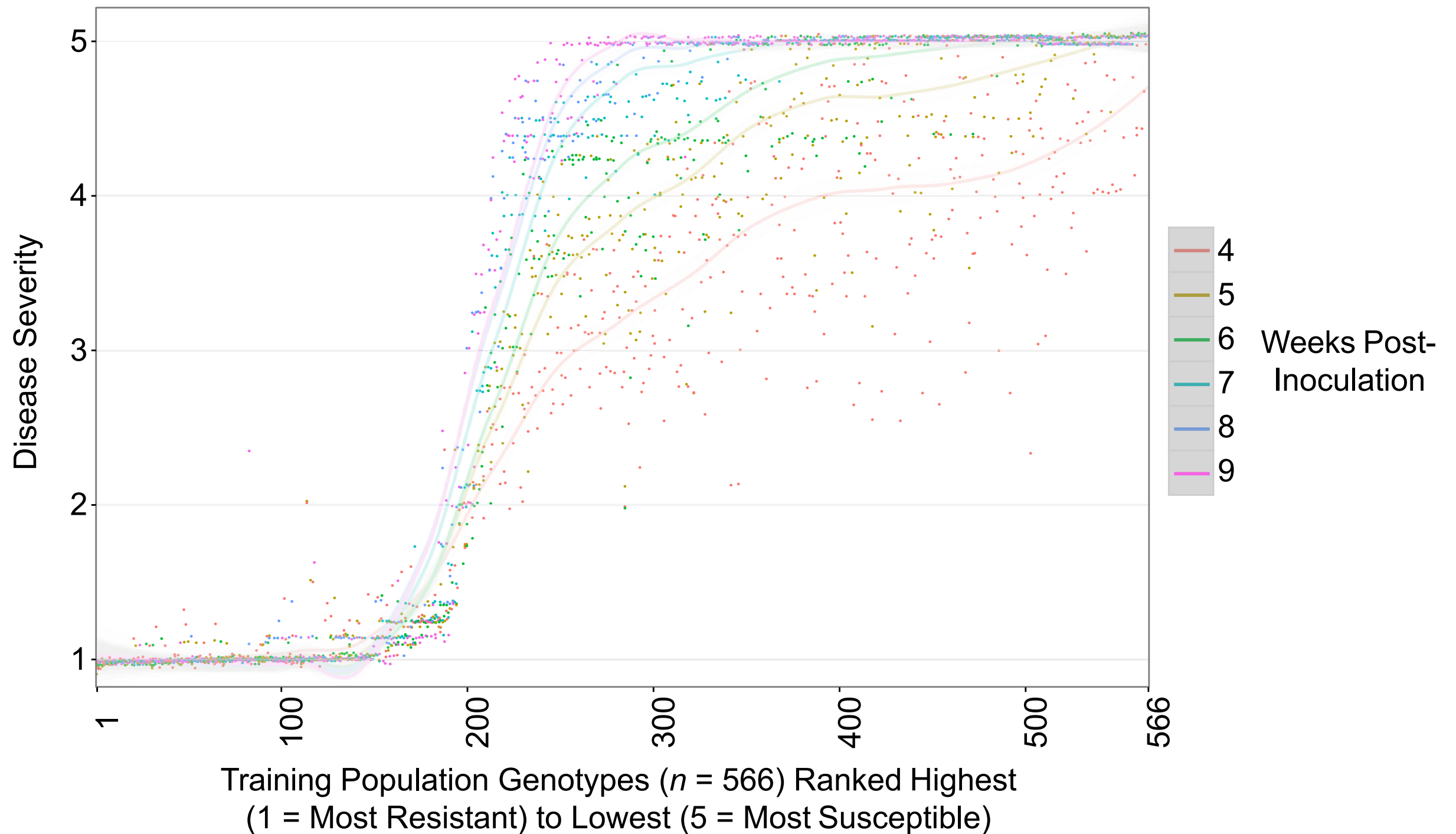
University of California
Agriculture and Natural Resources

GENOMIC PREDICTION AND GENOME-WIDE ASSOCIATION (GWAS) MAPPING

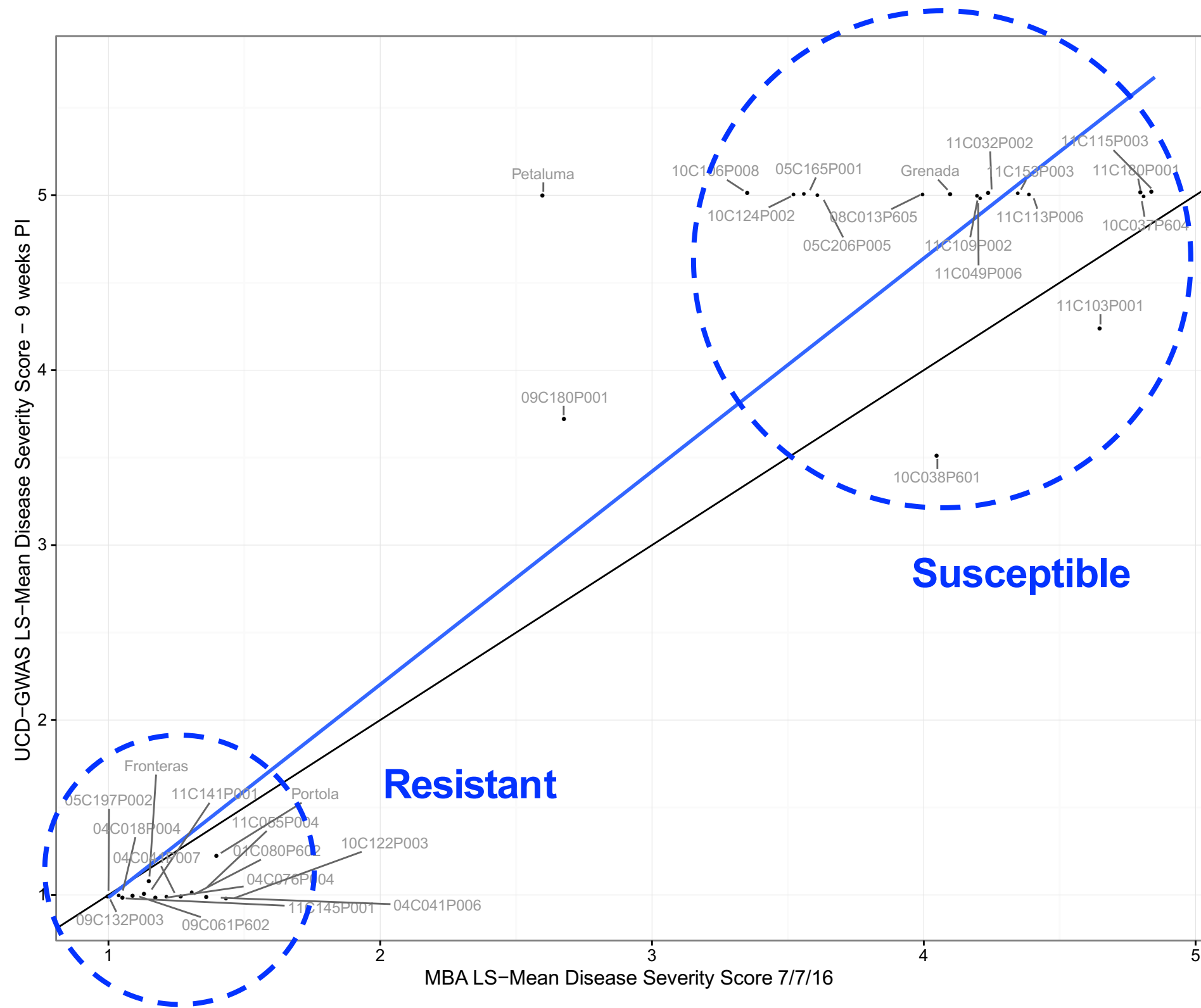
- 576 Core UC Genotypes
- 384 Non-UC Genotypes
- Small Number of Founders
- UC Genetic Diversity Has Been Very Widely Accessed and Proliferated in Public and Private Sector Breeding Programs



Phenotypes for Resistance to *Fusarium*: Distributions Predict Simple Genetics, Very High Heritability (0.98), Strong Alleles, e.g., Dominant Disease Resistance (R) Genes

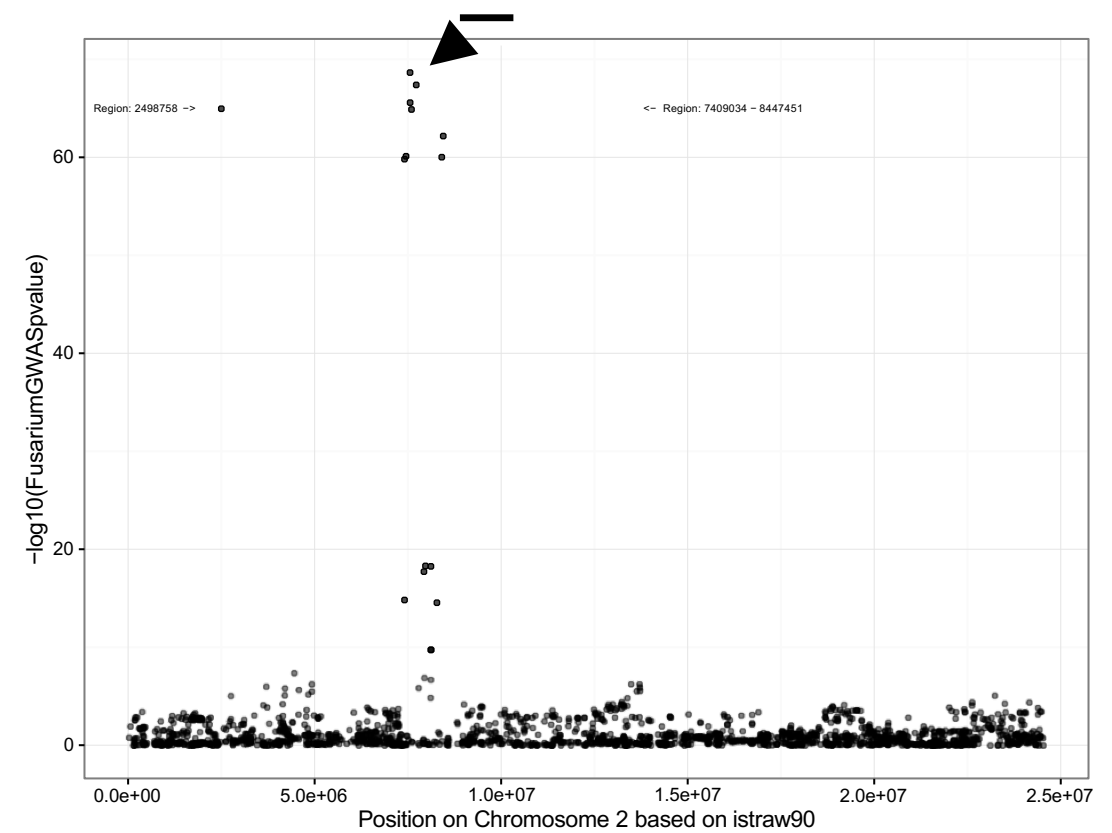
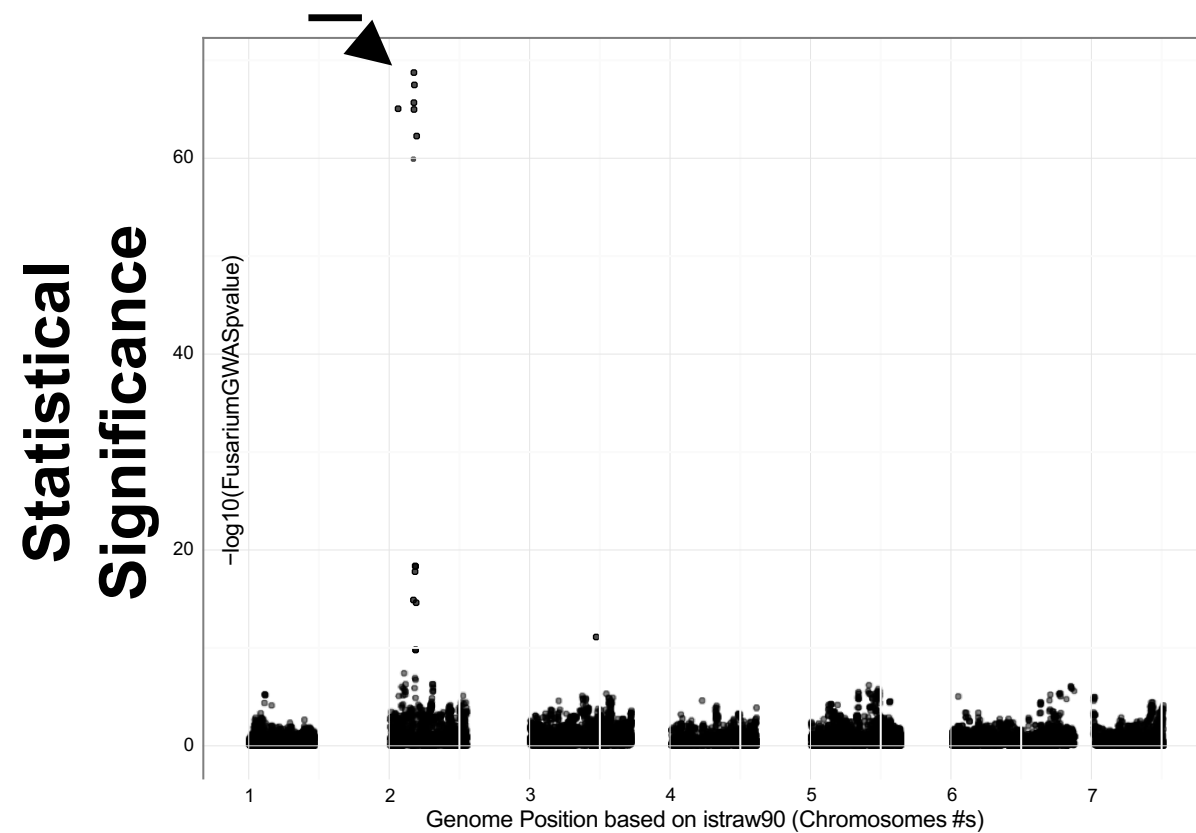


Phenotypes for Resistance to *Fusarium*: Natural Infection (X-Axis) Versus Race-Specific Artificial Inoculation (Y-Axis)



Genome-Wide Association Mapping (GWAS)

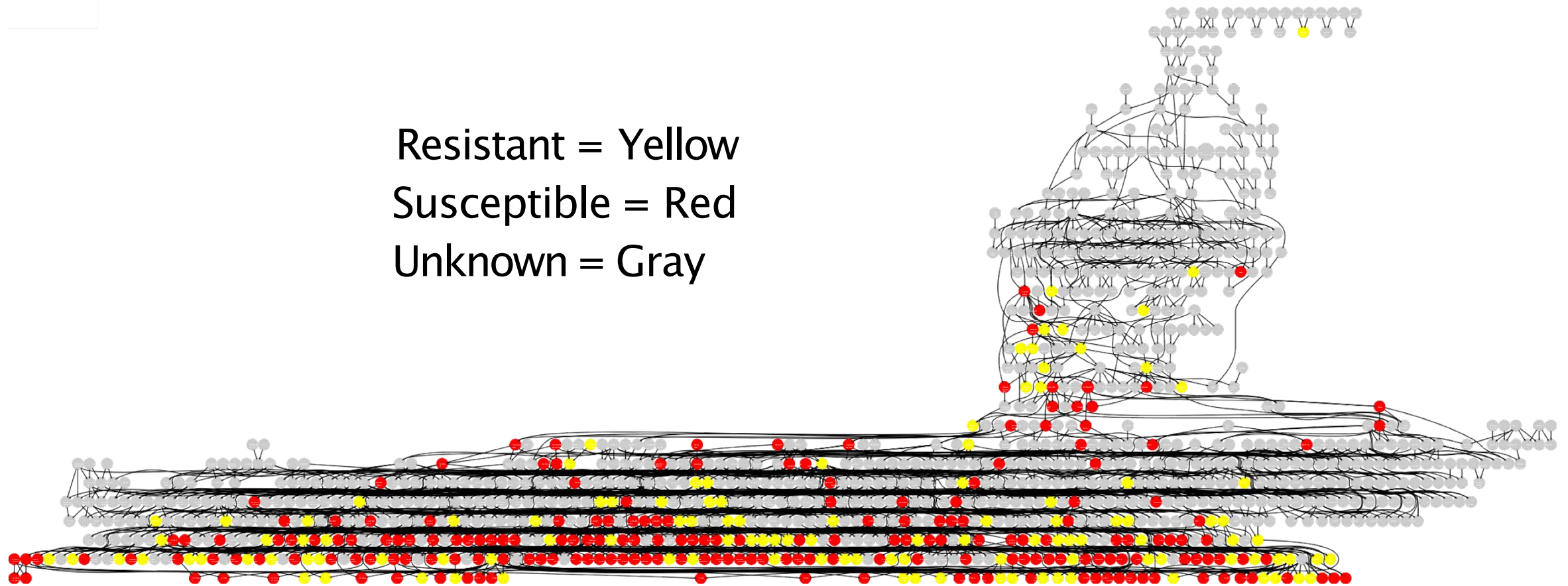
- ▶ Coupling Historic Recombination With Very High-Density Genotyping to Scan the Genome for Linkage Disequilibrium (LD) = Genotype-to-Phenotype Association
- ▶ Manhattan Plots: Very Strong LD Signals Predict a Single R-Gene or Cluster of R-Genes



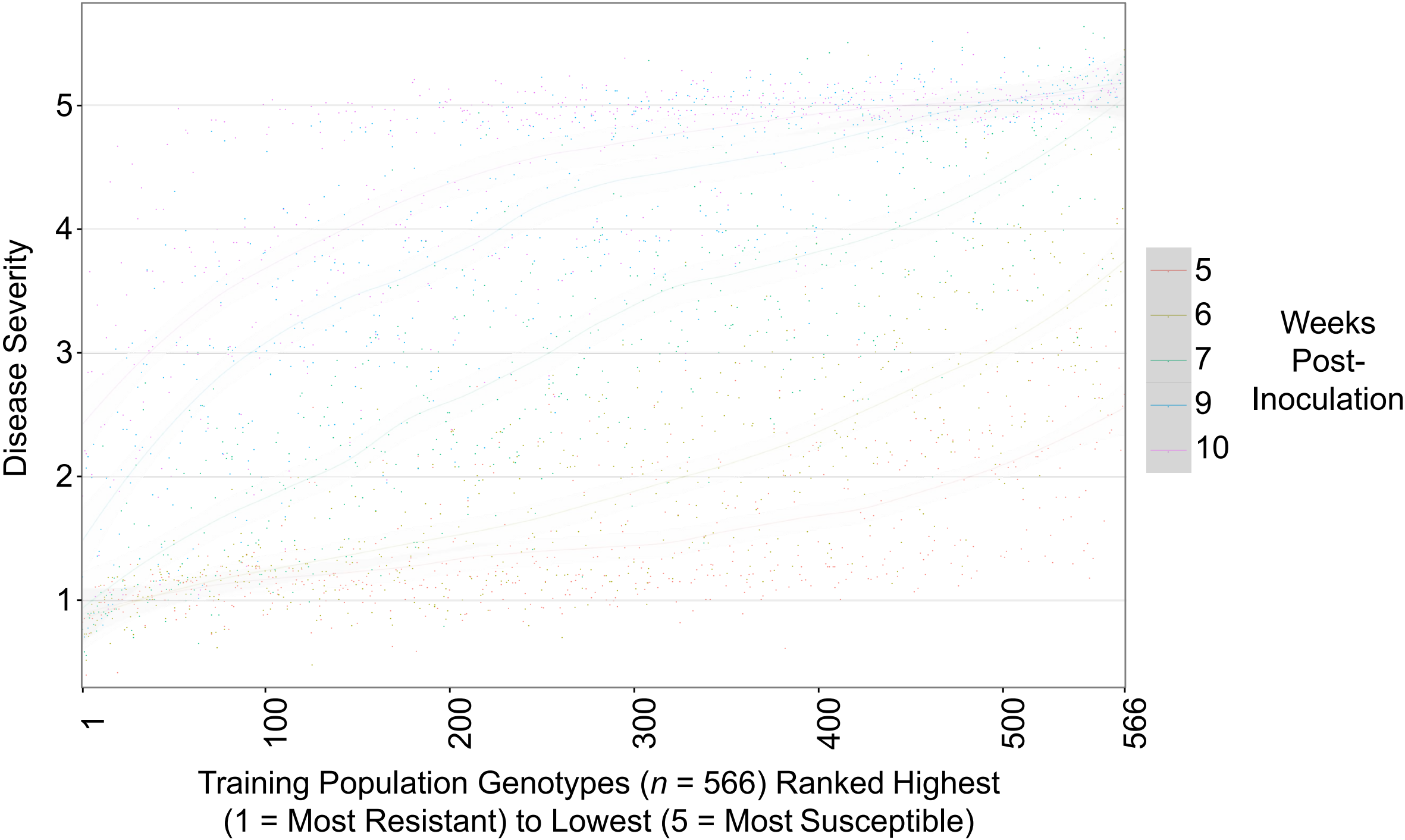
Chromosome (Genomic) Address

Distribution of the Hypothesized *Fusarium* Resistance Gene (*FUS2X*) Across UC Germplasm: GWAS Panel ($n = 566$)

Resistant = Yellow
Susceptible = Red
Unknown = Gray



Phenotypes for Resistance to *Macrophomina*: Distributions Predict Complex Genetics, Low Heritability (0.20), Weak Alleles (= Small Effects)



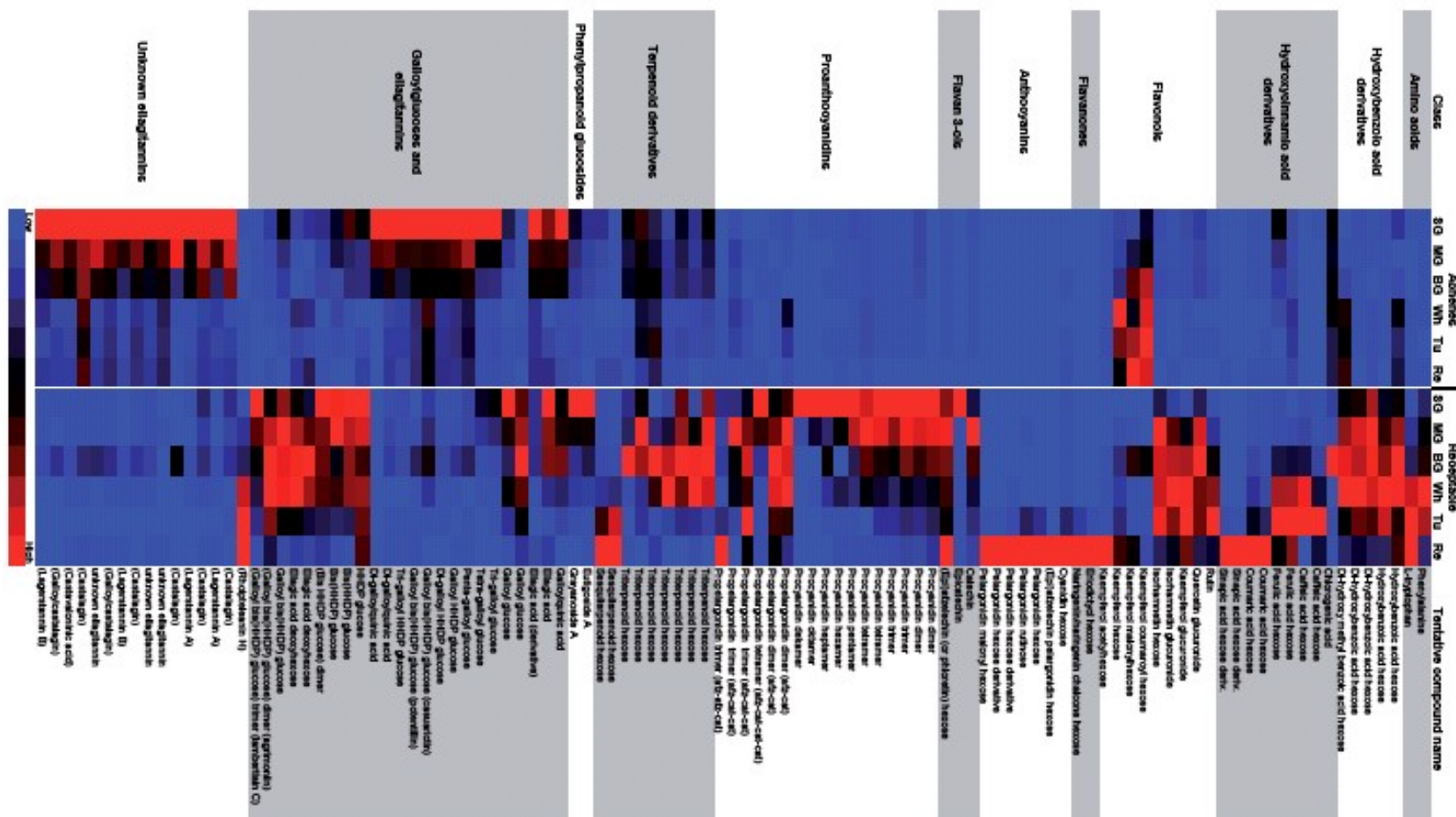
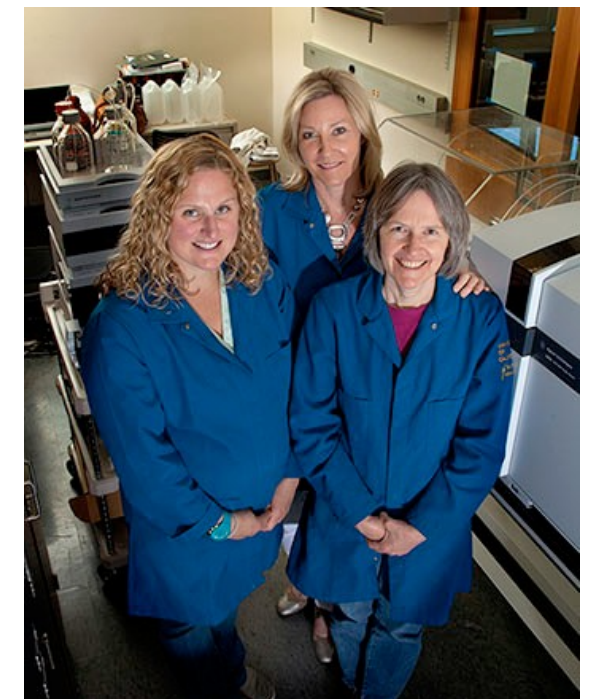
CONSUMER AND HEALTH BENEFITS INITIATIVE

AROMATICS, ANTI-OXIDANTS,
SUGARS, ACIDS, TEXTURE, COLOR



Metabolic Profiling of Primary and Secondary Metabolites in Strawberry Using GC-MS and LC-MS

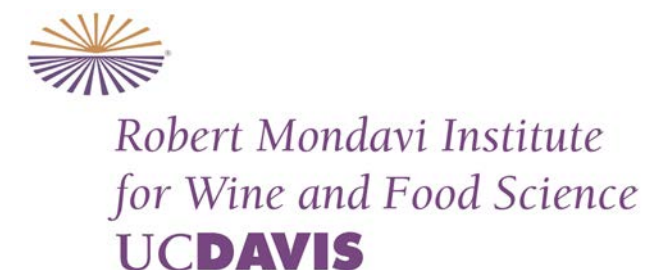
172 Metabolites × 6 Development Stages

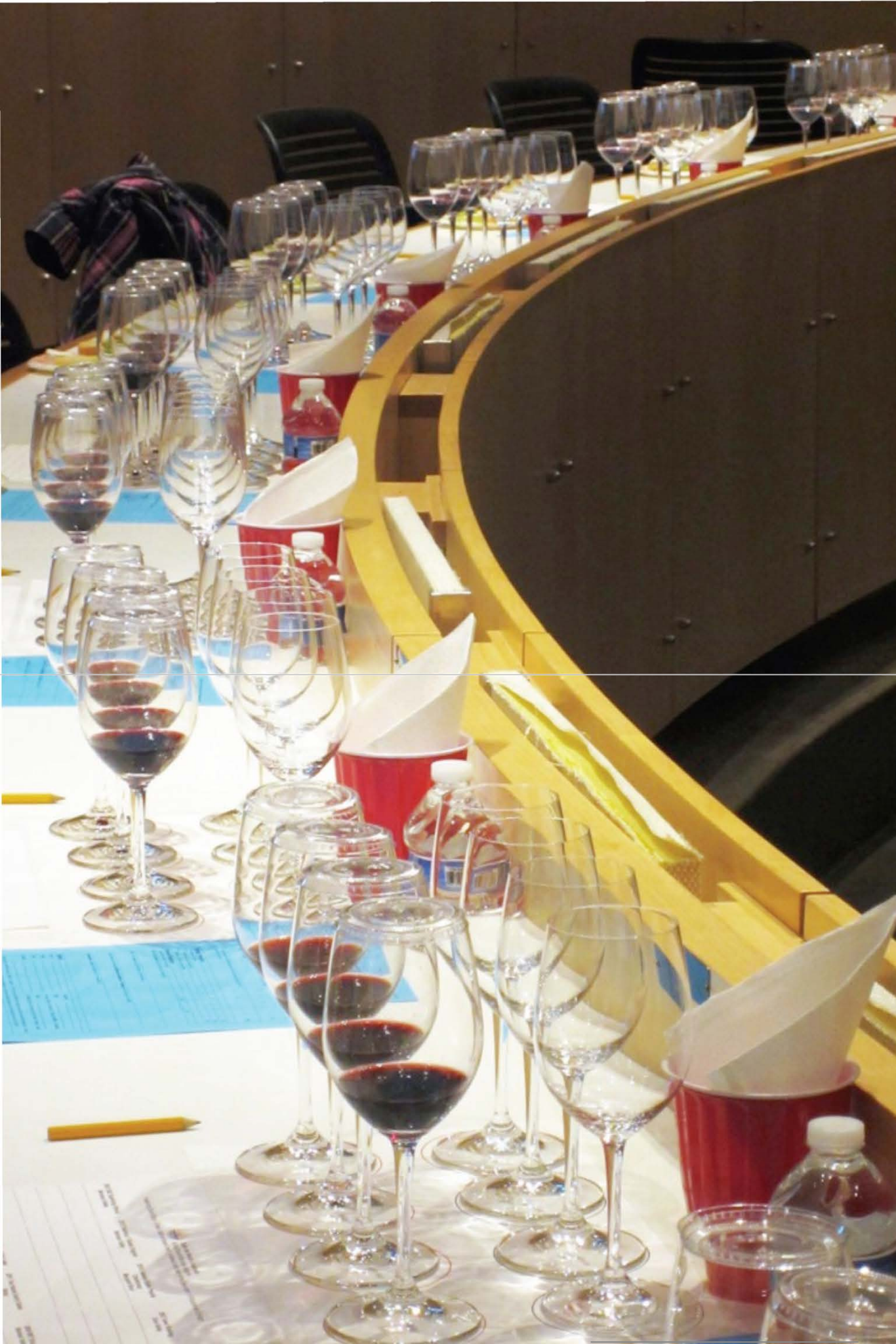


STRAWBERRY CONSUMER AND HEALTH BENEFITS INITIATIVE

FRUIT QUALITY, POST-HARVEST BIOLOGY, AND METABOLIC PROFILING

- ▶ Strawberry Fruit Quality Laboratory, Robbins Hall, UC-Davis
- ▶ Strawberry Fruit Quality Laboratory, UC ANR South Coast REC, Irvine
- ▶ Post-Harvest Technology Facility, Department of Plant Sciences, Wickson Hall, UC-Davis
- ▶ Agilent Food Safety and Measurement Facility, Department of Food Science and Department of Viticulture and Enology, Robert Mondavi Institute for Wine and Food Science
- ▶ Food Processing Pilot Plant, Department of Food Science, RMI
- ▶ Silverado Vineyards Sensory Theater, RMI





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- ▶ **Dan Legard, Rick Tomlinson, and Others, California Strawberry Commission**
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- ▶ **Issac Rainwater, Michael Carriere, and Clint Neagley, UC-Davis Innovation Access**



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