Smarter Farming with Smart Systems Drones and More

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http://www.ars.usda.gov/sp2userfiles/Place/20721500/images/rubus3.jpg

Nutritional Security: An Existential Threat

Food, Shelter, Fiber, Fuel > 9 billion

Path Forward

- Transformative discoveries
  - Smart Systems
  - Big Data
- 21st Century Extension
- Farming systems
  - 21st Century Farms
- Education
- Policies, regulation, marketing
- Human dimensions
- Communications

21st Century Farm

Outcome of Big Data and Analytics

2014 National Corn Yield Average: 171 Bushels
Randy Dowdy, farmer from Georgia: 503 Bushels

Randy Dowdy used sensors, optimal varieties, irrigation and fertilizers, pest control, and Big Data analytics with the help of Monsanto and Climate Corp

http://tinyurl.com/o78mah

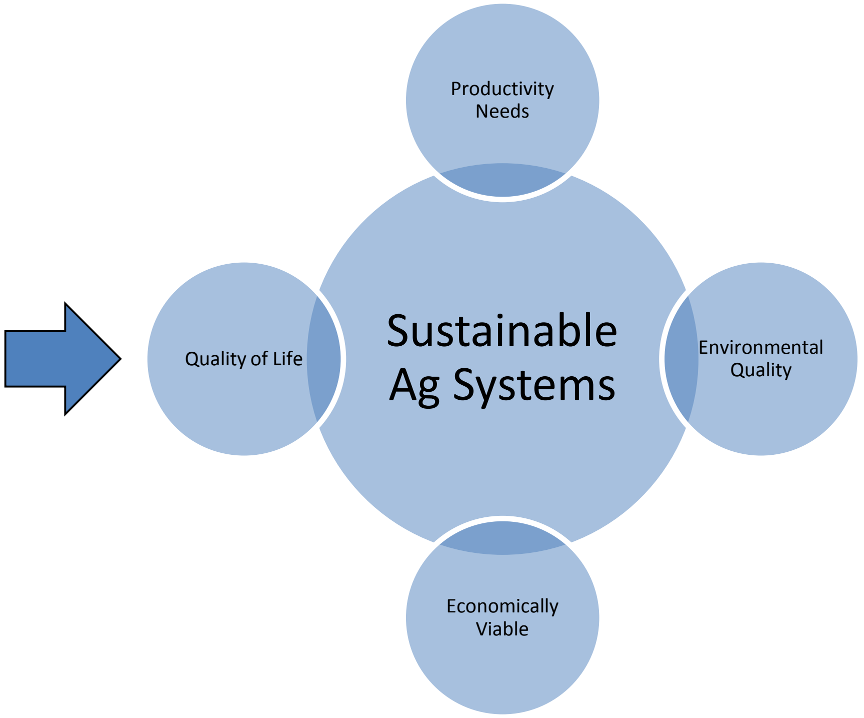
Smarter Caneberry Production??

Goal – Develop new or improved engineered devices, products, or systems that:

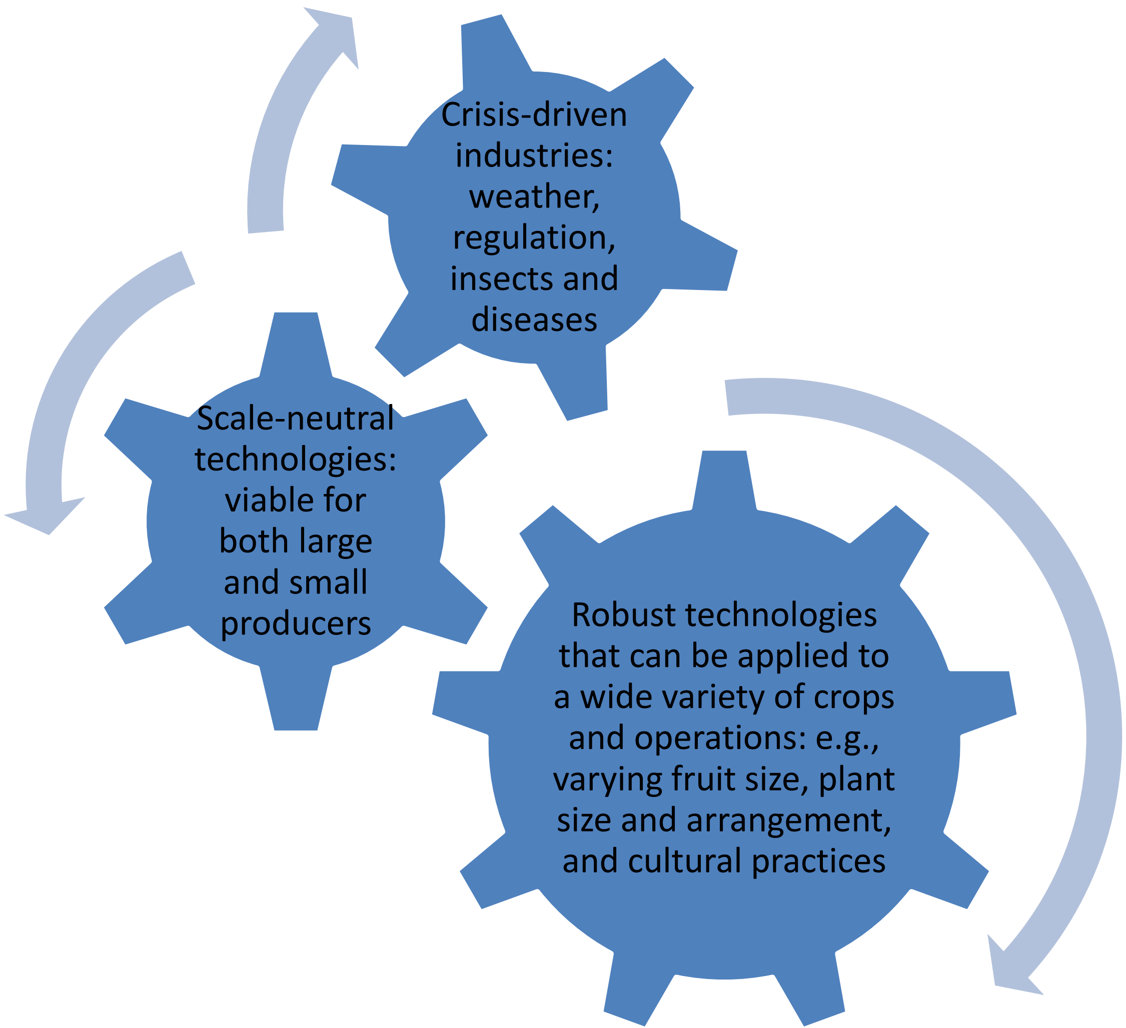
Precisely **sense**, "**reason**," and **respond**

Improve the **profitability**, **productivity**, and/or **efficiency** of ag-related operations of all sizes

Benefit consumers and **society**



Technology challenges



Agricultural Robotics

While producing **safe, nutritious, and affordable food** to serve a growing global population—as well as feed, fiber, and fuel—the agricultural enterprise **consumes large amounts of land, water, and petro-chemicals**.

↓

Availability and cost of farm labor has created an economic disadvantage for many agricultural industries in the U.S. as they try to **compete** in the **global marketplace**.

↓

Robotics can help agriculture be more productive and efficient, and reduce its footprint in consuming resources and generating waste.

↓

Using robotics to eliminate unskilled, unsafe, and low-wage jobs will create **new business opportunities**, with higher-wage, technically demanding jobs, that can lead to **more viable and resilient rural economies**.

Sustainability

Agriculture is a science and engineering enterprise

How does this translate to blackberry and raspberry breeding?

What can smart systems do?

1) Assist in the berry production process
2) Measure plant performance
3) Track environmental conditions
4) Inform real-time decision making

DEVELOPING NEW TECHNOLOGIES

DESIGNING SMART SYSTEMS FOR BETTER BERRIES

Designing sensors, robots, and drones to measure environments and traits, production to post-harvest

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Field production application to caneberries:

- Plant crops using precision tractors with GPS locators
- Develop machines for pruning and training
- Robotic weeding

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SCREENING GENOTYPES AND PHENOTYPES

Combine **next-generation sequencing** & **new sensor technologies** to acquire genotype, phenotype, and environmental data to **identify relationship between genotype and phenotype**

Long-term goal: **accelerate breeding** via marker-assisted selection and genomic selection to aid rapid seedling screening

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Generating large quantities of environmental, trait, and genetic data

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Challenges: Blackberry ploidy level, Optimizing cost/benefit of bramble genomic resources

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New technologies, statistical tools, and experimental design strategies are decreasing the costs of marker-assisted breeding

NIFA-funded RosBREED researchers are developing blackberry genetic markers (sweetness), leveraging genetic resources from closely related Rosaceous species

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<u>What to measure?</u>

-**Pest** and **disease resistance** in raspberry (e.g., root rot, bushy dwarf virus, aphid resistance)
-**Plant traits** (e.g., taste, yield, berry firmness)
-**Environments** (e.g., soil moisture for precision irrigation)

DESIGNING SMART SYSTEMS FOR BETTER BERRIES

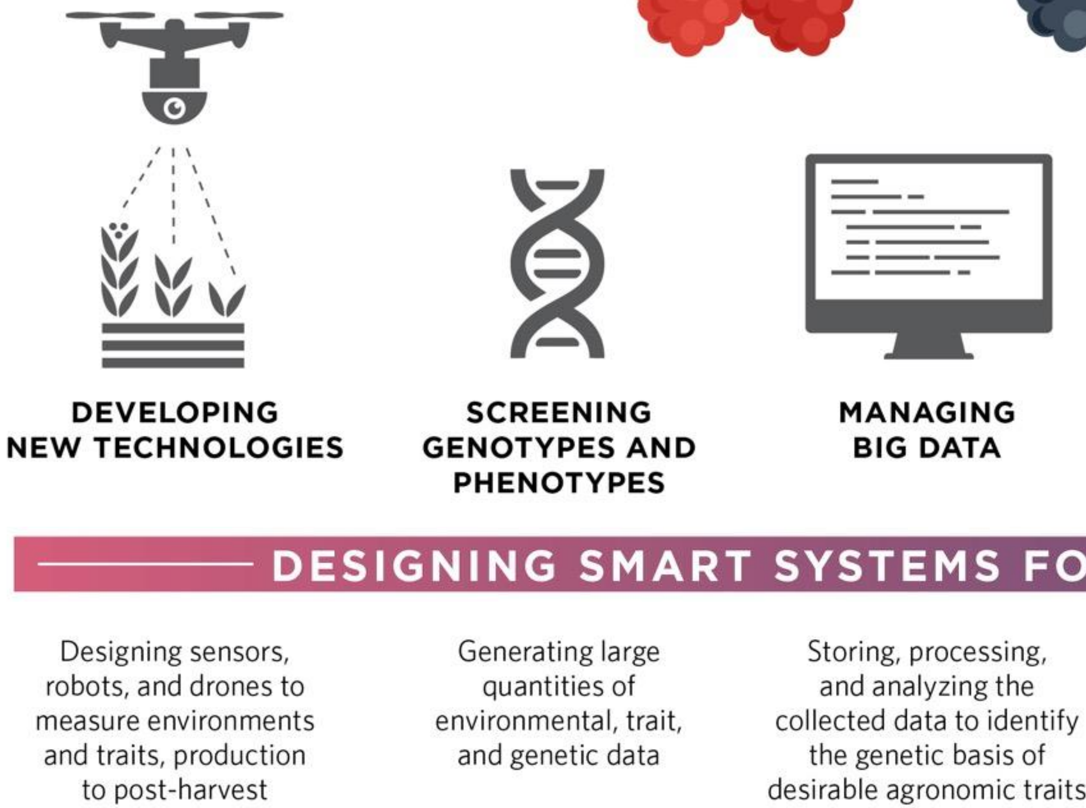
<u>How might this look in the field?</u>

Example: Use drones equipped with infrared cameras to identify poorly performing field plots

An example of phenotyping in the field, from grape

Video courtesy of Dr. Stephen Nuske

Smart systems generate lots of data



Storing collected **raw data**

Using **algorithms** to **generate results** from the raw data

Modeling to develop **understanding** of the data, **inform breeding** selections and field trials

#BigData

Big Data: Milieu

- Analytics
- Informatics
- Evidence-Based Tools
- Meta-Analysis and Synthesis
- Complex Systems
- Computational Sciences
- Data Engineering
- Data Mining
- Cloud Computing
- Implementation and Evaluation
- Data Security and Cybersecurity
- Predictive Modeling
- Data Visualization
- Decision Analytics
- Embedded Systems
- Machine Learning
- Multidimensional Data
- Network Science
- Sensor Networks
- Spatial Analytics
- Bandwidth
- Cyberphysical Systems

Big Data: Challenges

- Ownership
  - Open Ag Technology Systems
- Decision Support Tools
  - Open Ag Toolkit – NIFA funded
  - FarmBot
- Cost
- Bandwith
- Quality
- Curation
- Disambiguation
- Connectivity
- Cybersecurity
- Storage

Courtesy: Dennis Buckmaster; https://engineering.purdue.edu/oatsgroup/

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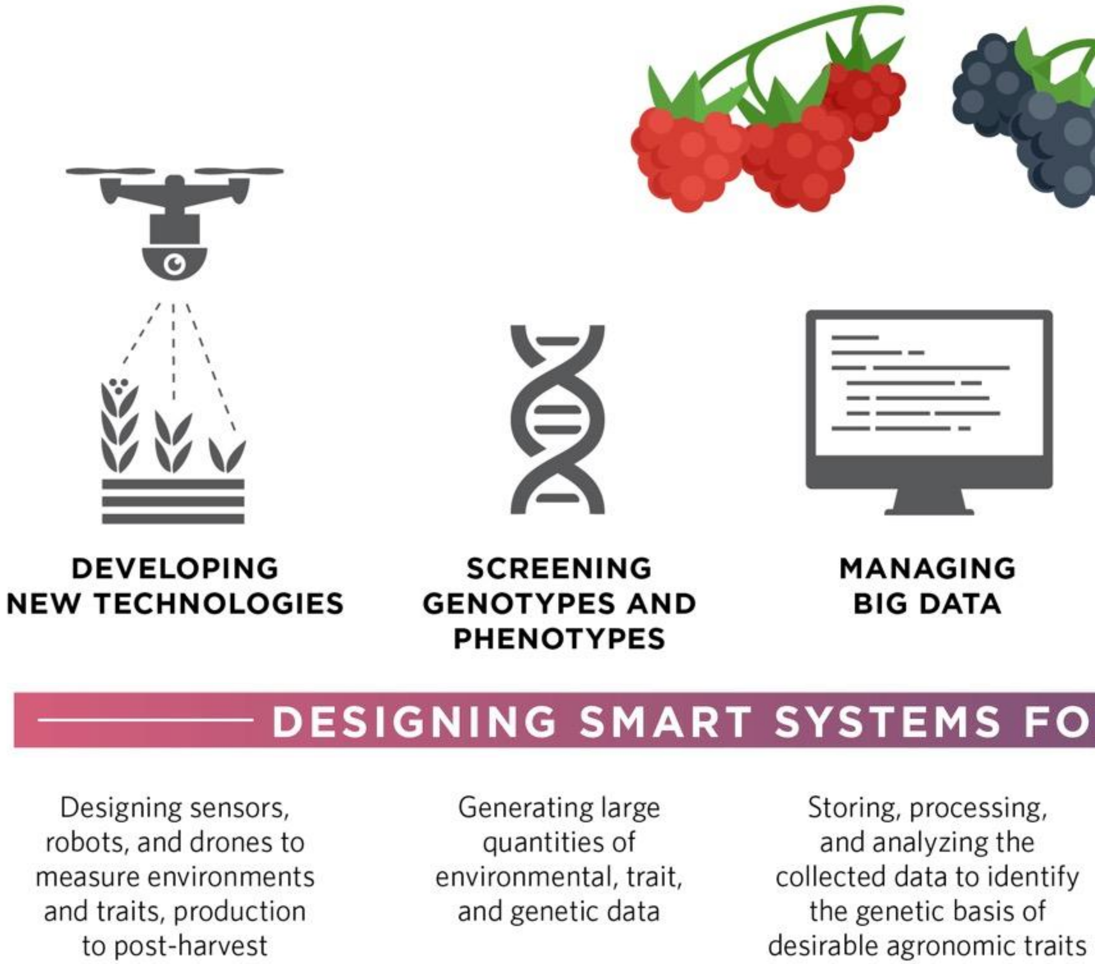

Need for education of workforce with the relevant knowledge and skills

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MANAGING BIG DATA

Storing, processing, and analyzing the collected data to identify the genetic basis of desirable agronomic traits

BREEDING DESIRABLE CROP VARIETIES

Selecting, genetically screening, field testing, and scaling desirable varieties for production

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GPS harvesters that weigh fruit create yield maps, correlate with soil data to improve field uniformity, performance

Future goal:
Use sprayer technology to apply fertilizers, pesticides only where needed

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HARVESTING & DISTRIBUTING TO CONSUMER
Using new technologies to harvest and transfer high-quality berries from farm to table

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Application to caneberries:

State-of-the-art machine harvesters in the Pacific Northwest optimize efficient harvest of high quality fruit for the Individually Quick Frozen market

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& DISTRIBUTING
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DESIGNING SMART SYSTEMS FOR BETTER BERRIES

Color and size sorters ensure quality products in the fresh and processed packing industries

Using new technologies to harvest and transfer high-quality berries from farm to table

Photos courtesy of Dr. Bernadine Strik, Oregon State University

Harvest and post-harvest robotics: examples from blueberry and strawberry

Photo courtesy of Dr. Changying Li, University of Georgia

<u>Berry Impact Recording Device</u>: wireless postharvest data logging sensor

Aids in selecting blueberries that can withstand mechanical stress during harvesting, post-harvesting, shipping, and handling

<u>Frail-bots</u>:
Inexpensive, relatively small, harvest-aiding robots

Reduces harvesting time by transporting hand-picked crops

Protects worker health by reducing slipping accidents

Video courtesy of Dr. Stavros Vougioukas, University of California Davis

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Keys to success moving forward

- Developing new technologies via **private-public partnerships**, transdisciplinary **collaborations**
- Using new **technologies** to build upon existing discoveries, **complement the breeders' eye**: e.g., primocane, spinefree, disease resistance
- **Education** of a new, more broadly trained ag workforce

"Genetic diversity remains the foundation of crop improvement, and anything that helps in identifying or expanding diversity will lead to more great discoveries."

-- Dr. John Clark, University of Arkansas blackberry breeder

Fruit Grower News, October 2015

21st Century Farm

http://tinyurl.com/o78mah

Humans Matter