USDA United States Department of Agriculture — Office of the Chief Scientist

Visioning of United States, (U.S.) Agricultural Systems for Sustainable Production Stakeholder Listening Session Meeting

Thursday, March 2, 2017 8:30am – 4:30pm USDA South Building Cafeteria

Welcome!

- Bathrooms between cafeteria and security entrance
- Safety – nearest exit towards south side of building
- WiFi access USDA-Guest
  - **Name: patio**
  - **Password: test123**
- Teleconference and WebEx participants
  - May take questions from WebEx chat
- Public listening session – will attempt to record session
  - All comments, written and oral may be used in any form (including edited for length, in print, web, etc.)

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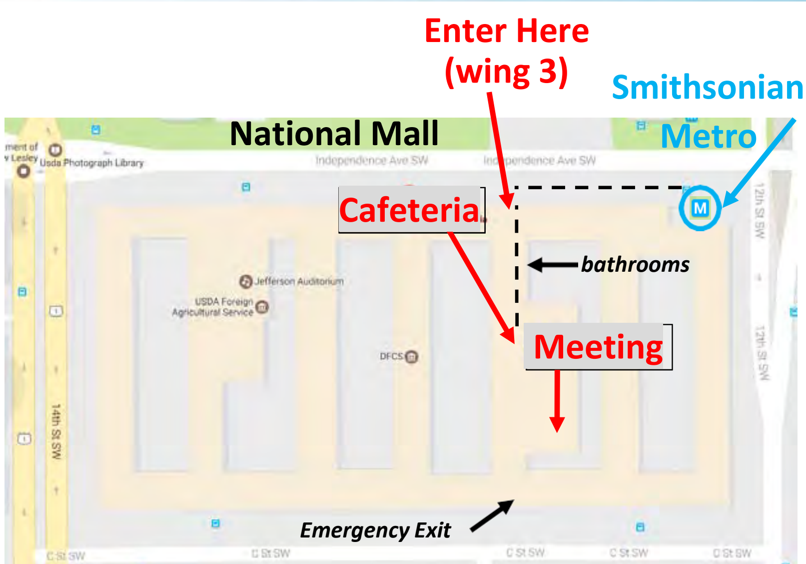

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Welcome!

- Research discussion, what avenues of science can hold
  - In no way connected to policy
- Focused on longer-term future
- We want to acknowledge there are areas of disagreement without squishing them, but try to move on to get to consensus areas.
- Sara Scherr is helping to facilitate because of her expertise in these activities

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Structure

- Few invited presentations
- Stakeholder presentations – somewhat grouped
- Pooled time for questions and discussion
- Breakout sessions – questions in slides, email and back of agenda

- Notecards are for questions comments, etc. to go in written record
- Use easel pads for group discussions

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Office of the Chief Scientist

- Ensures the Chief Scientist is the leading communicator of USDA Science nationally & internationally
- Advises the Secretary & Departmental Leadership
- Ensures a Department-wide culture of science-based decision making for science policy
- Raises the visibility of USDA Science
- Institutes, maintains, & enhances USDA's Scientific Integrity Policy

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Dr. Ann Bartuska

Acting Under Secretary, Research, Education, and Economics
USDA

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Brainstorming Approach – Beginning a Conversation

- Focus on agricultural production systems 50 years from now
- Consider how to integrate basic scientific discoveries and technology
- Please be
  - Open minded
  - Visionary
  - Bold in new ideas
  - Use systems thinking – across silos, disciplines, and commodities

What is something you wish people understood better, that would make your area of agriculture more successful?

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 # 1

Dr. Elise Golan

Director for Sustainable Development
Office of the Chief Economist
USDA

https://www.usda.gov/oce/sustainable/definitions.htm

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https://www.usda.gov/oce/sustainable/definitions.htm

Farm Bills: The 1977 and 1990 "Farm Bills" describe sustainable agriculture as an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- satisfy human food and fiber needs;
- enhance environmental quality and the natural resource base upon which the agricultural economy depends;
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls;
- sustain the economic viability of farm operations;
- enhance the quality of life for farmers and society as a whole.

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 # 2

Dr. Charles Walthall

National Program Leader
Natural Resources and Sustainable Agricultural Systems
Agricultural Research Service
USDA-ARS

Precision Agriculture

- Sensing & mapping: stratify field into management zones
  - Conditions & capacity
- Tailor inputs & treatments to management zone (vs whole field)
  - Variable inputs: time & space
  - Yield maps
- Multiple objectives: Yield, economics, environment
- Livestock: Track animal location & health, forage status

"Efficiency"

Walthall – USDA ARS

Remote Sensing

- Information: Spatial, spectral, temporal, bidirectional, polarization & phase
- Platforms: "On the go", handheld, UAV, aircraft, spacecraft
- Processing: Calibration, formatting to map, analysis product
- Analysis:
  - Scouting "Cheat sheet"
  - Soil conditions
  - Crop conditions

"Condition & Capacity"

Walthall – USDA ARS

"Decision Support"

- Information for producer, land manager: *"Options"*
- Real-time & Retrospective analysis
- Genetics x Environment x Management interactions: ***GxExM***

- Lots of data – analysis?
  - "Big Data" tools?
  - Models for "what if?" scenarios
- Potential not realized; adoption rates?
- R&D: Roles for public funding, industry

Walthall – USDA ARS

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 # 3

Dr. Mitch Tuinstra

Professor and Wickersham Chair of Excellence
Department of Agronomy
Purdue University

DOE ARPA-E

PURDUE UNIVERSITY | PHENOMICS IBM



MULTI-SCALE ANALYSIS OF FIELD-GROWN CROPS TO ENHANCE CROP IMPROVEMENT AND PRODUCTION RESEARCH

Mitch Tuinstra[1], Christopher Boomsma[1], Javier Ribera[1], Yuhao Chen[1], Fangning He[1], Weifeng Xiong[1], Zhou Zhang[1], Addie Thompson[1], Karthikeyan Natesan Ramamurthy[2], Aurelie Lozano[2], Naoki Abe[2], Ayman Habib[1], Edward Delp[1], Larry Biehl[1], Michael Leasure[1], Keith Cherkauer[1], Clifford Weil[1], and Melba Crawford[1]

[1]Purdue University, West Lafayette, IN
[2]IBM Research, Yorktown Heights, NY

March 2 listening session

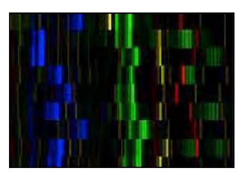
PRECISION PHENOTYPING – LINKING GENES TO PHENOTYPES

Environmental Adaptation

Climatic and Edaphic Variables

Genetic Diversity

High-value population in many crops and models



Phenotypic Characterization

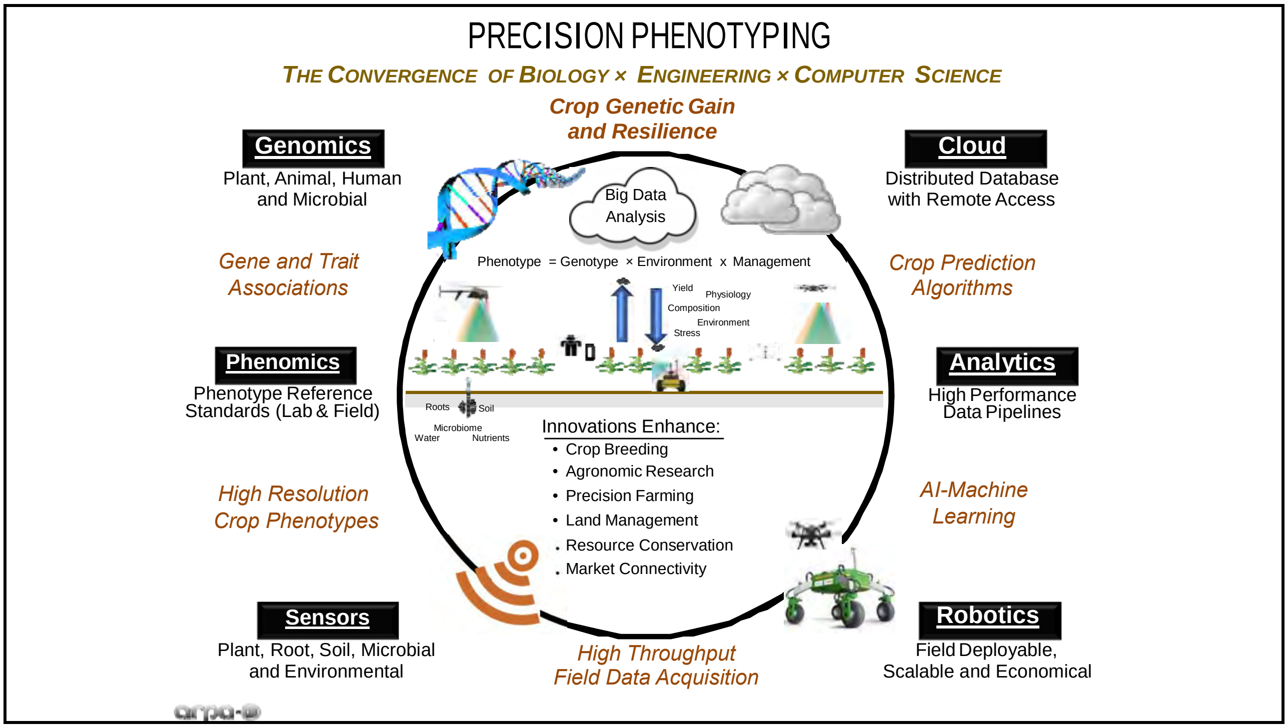
- Yield Potential
- Abiotic Stress Adaptation
- Disease Resistance
- Plant Architecture
- Quality

Genetic Information

- Genomic profiles to estimate genetic relationships
- Gene-based markers
- Pedigrees

A BIG "Big Data" Challenge and Opportunity

arpa-e



SMARTER AGRICULTURE

MORE EFFICIENT CROP IMPROVEMENT AND AGRONOMIC RESEARCH PLATFORMS

Smarter Agriculture™ platforms will provide plant science researchers with a data management infrastructure that will organize data from many disparate streams in a cohesive way for more robust analysis in a secure framework that allows collaboration, data reuse and publication.

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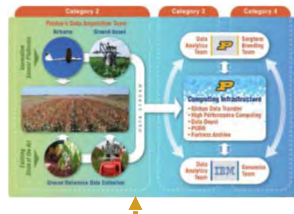
AUTOMATED CROP PHENOTYPING PLATFORMS

DOE ARPA-E TERRA PROGRAM FOR HIGH-THROUGHPUT SORGHUM PHENOTYPING

Purdue University
- Larry Biehl: information technology
- Christopher Boomsma: crop physiology, phenotyping
- Keith Cherkauer: UAV technology, remote sensing
- Melba Crawford: remote sensing, machine learning
- Edward Delp: image and video processing
- David Ebert: visual analytics
- Ayman Habib: digital photogrammetry, LiDAR
- Michael Leasure: UAV technology and operations
- Addie Thompson: quantitative genetics
- Mitch Tuinstra: plant breeding, genetics
- Clifford Weil: plant genomics

IBM
- Naoki Abe: machine learning, data mining
- Upendra Chitnis: data warehousing, spatio-temporal databases
- Aurelie Lozano: high-dimensional data analysis
- Peder Olsen: machine learning
- Karthikeyan Natesan Ramamurthy: machine learning

University of Queensland
- Scott Chapman: crop modeling, phenotyping
- Graeme Hammer: crop modeling



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IBM

University of Queensland

Industry Partners
- Applanix
- AgReliant Genetics
- John Deere

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DATA ACQUISITION PLATFORMS

REMOTE SENSING TECHNOLOGY

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GROUND VALIDATION STUDIES

IN SITU DATA ACQUISITION

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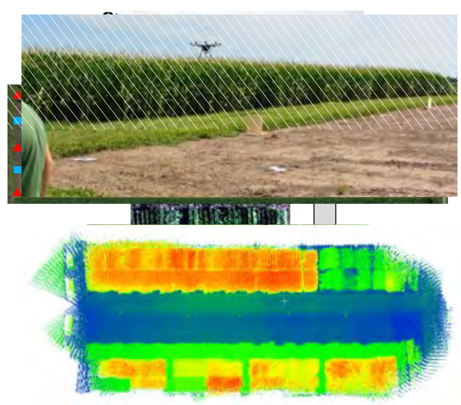
GEOMETRIC CORRECTION

DATA PROCESSING

- System Calibration
- RGB Image Data Processing
- Hyperspectral Image Data Processing
- LiDAR Data Processing

GNSS/INS Integration



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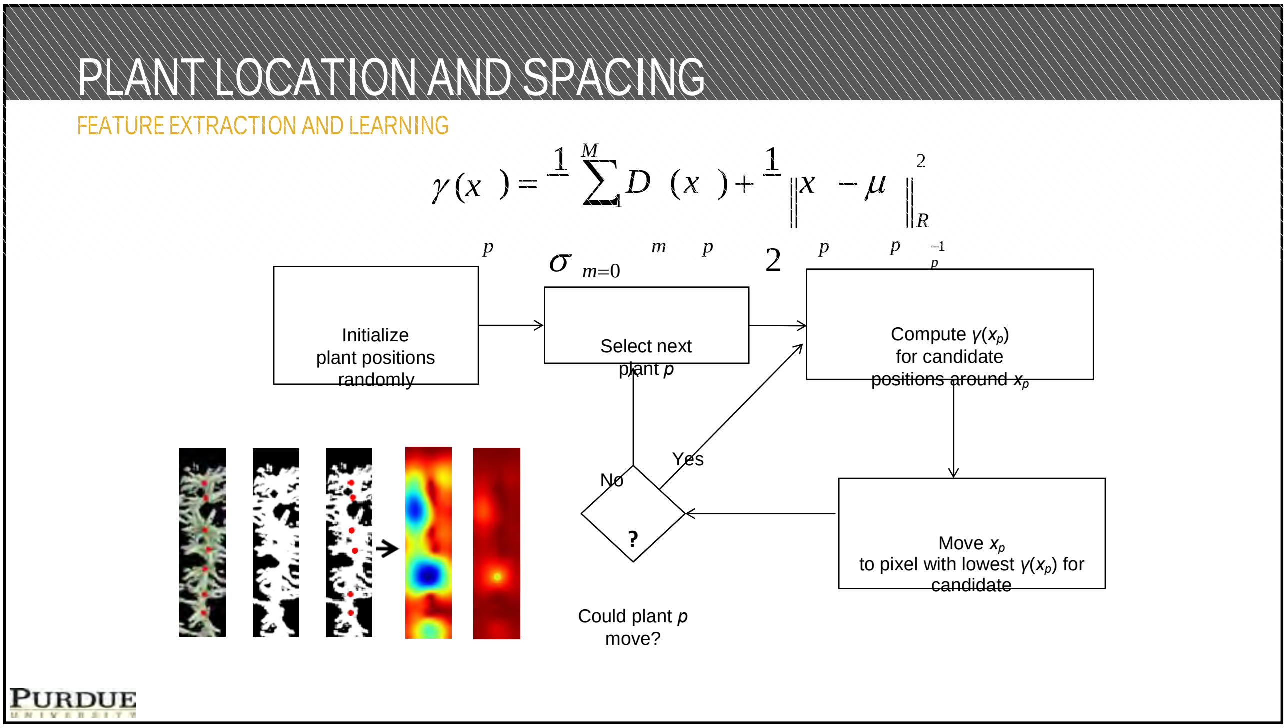
PLANT LOCATION AND SPACING
FEATURE EXTRACTION AND LEARNING
Initialize plant positions randomly
Select next plant p
Compute γ(x_p) for candidate positions around x_p
Move x_p to pixel with lowest γ(x_p) for candidate
Yes
No
?
Could plant p move?
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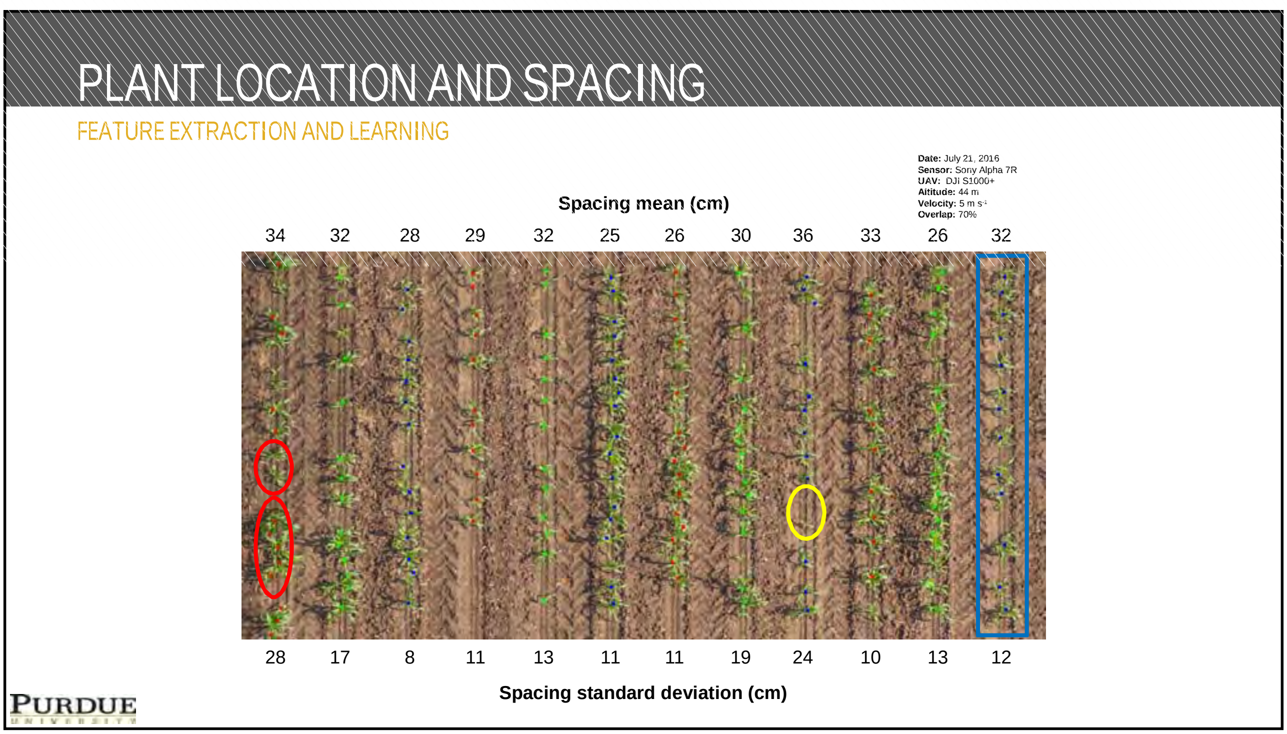
PLANT LOCATION AND SPACING
FEATURE EXTRACTION AND LEARNING
Date: July 21, 2016
Sensor: Sony Alpha 7R
UAV: DJI S1000+
Altitude: 44 m
Velocity: 5 m s-1
Overlap: 70%
Spacing mean (cm)
34 32 28 29 32 25 26 30 36 33 26 32
28 17 8 11 13 11 11 19 24 10 13 12
Spacing standard deviation (cm)
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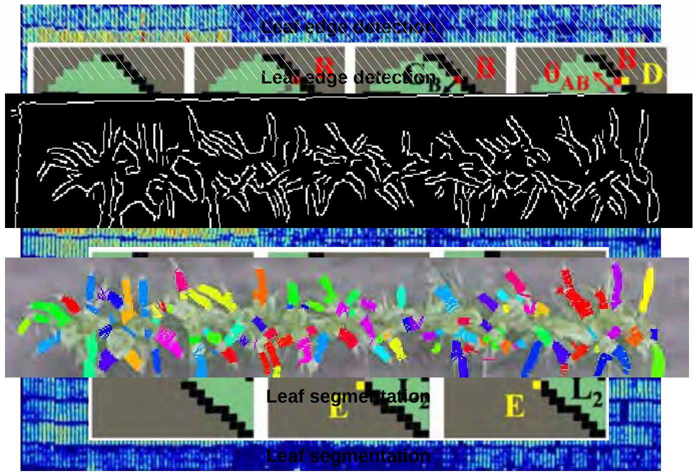
LEAF NUMBER

FEATURE EXTRACTION AND LEARNING



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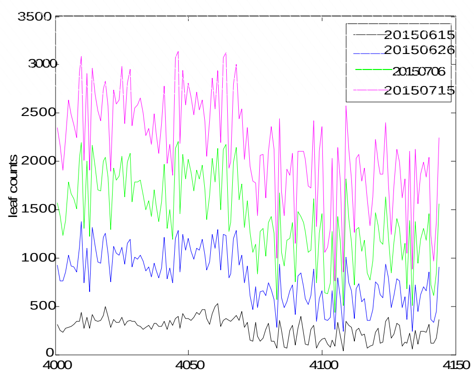
LEAF NUMBER FROM CUMULATIVE COUNTS

FEATURE EXTRACTION AND LEARNING



Average	20150615	20150626	20150706	20150715
Accumulated Leaf counts	271.9	802.8	1431.7	2146

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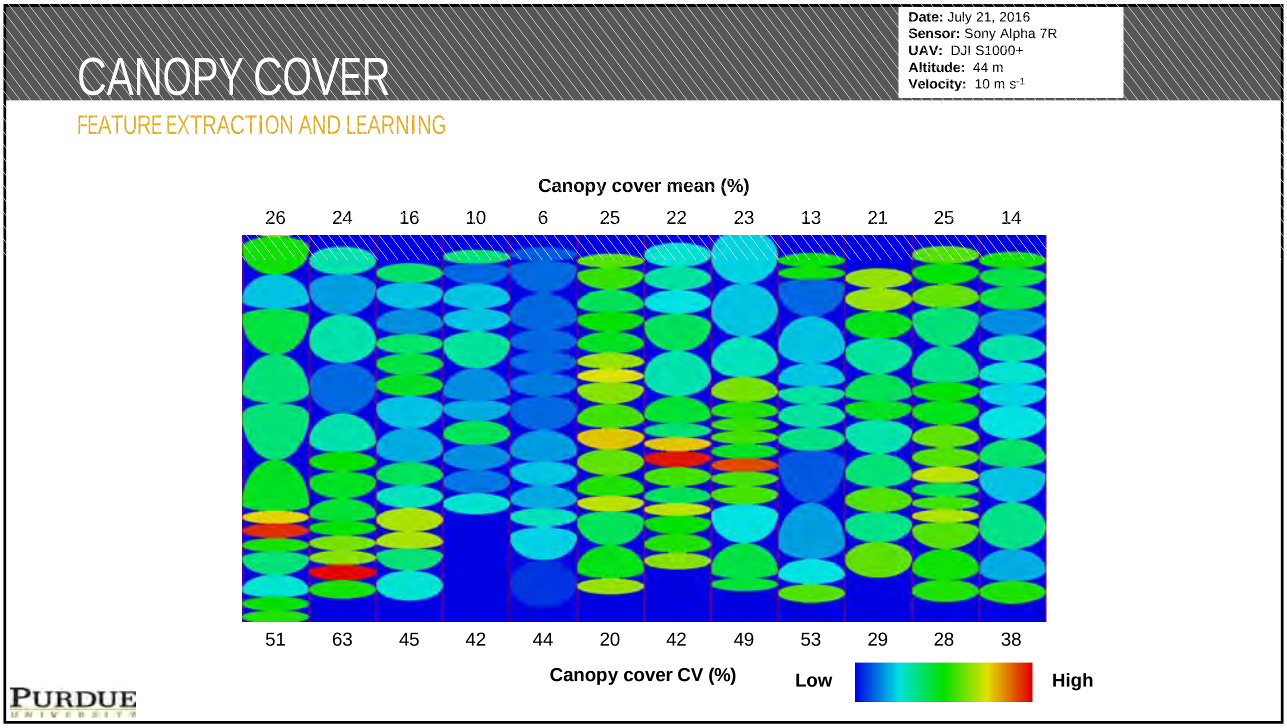
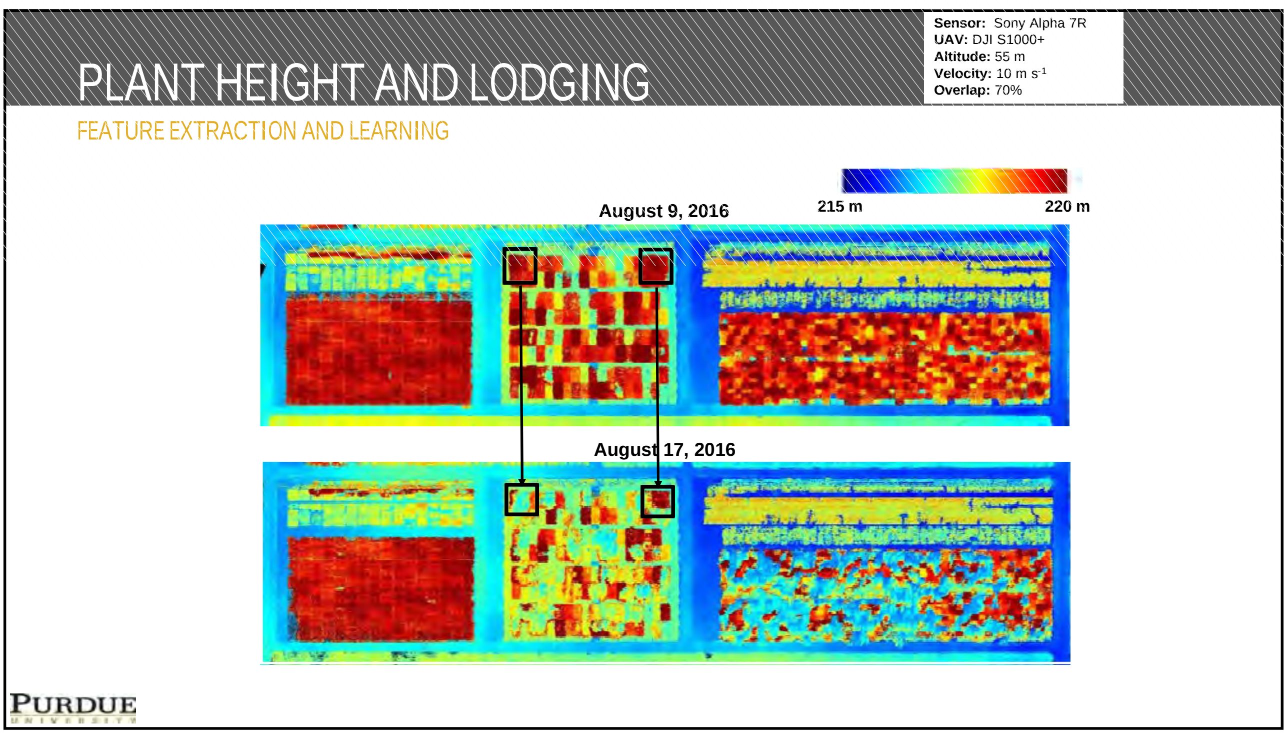
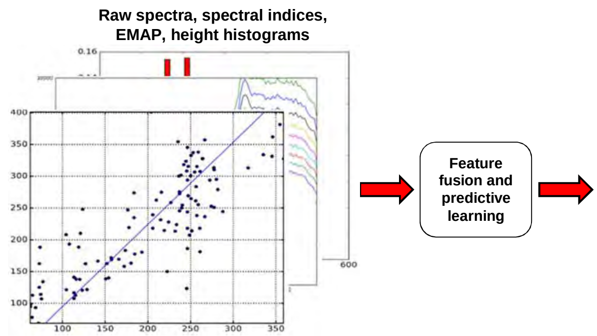

Date: July 21, 2016
Sensor: Sony Alpha 7R
UAV: DJI S1000+
Altitude: 44 m
Velocity: 10 m s-1
CANOPY COVER
FEATURE EXTRACTION AND LEARNING
Canopy cover mean (%)
26 24 16 10 6 25 22 23 13 21 25 14
51 63 45 42 44 20 42 49 53 29 28 38
Canopy cover CV (%)
Low
High
PURDUE


Sensor: Sony Alpha 7R
UAV: DJI S1000+
Altitude: 55 m
Velocity: 10 m s-1
Overlap: 70%
PLANT HEIGHT AND LODGING
FEATURE EXTRACTION AND LEARNING
215 m
220 m
August 9, 2016
August 17, 2016
PURDUE

PREDICTIVE LEARNING

LATENT FEATURE EXTRACTION

Multi-modal data provide a unique challenge for data fusion and phenotype prediction.



Phenotypic trait prediction performance

Phenotype	RMSE	R^2	Bias (%)
Plant height	32.44 cm	0.80	3.05
Stem diameter	3.01 mm	0.52	0.50
Stem volume (DE)	80.56 cm^3	0.23	5.27
Stem volume (PE)	71.01 cm^3	0.25	6.38

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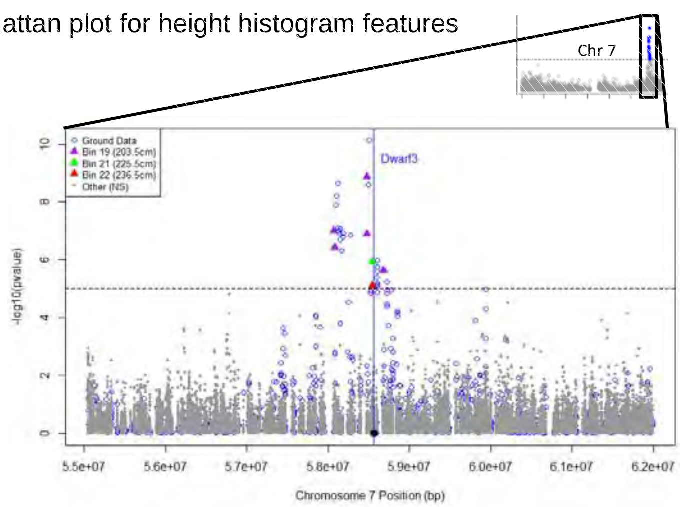
GENE DISCOVERY STUDIES – PLANT HEIGHT

GENOME WIDE ASSOCIATION STUDIES

Manhattan plot for height histogram features



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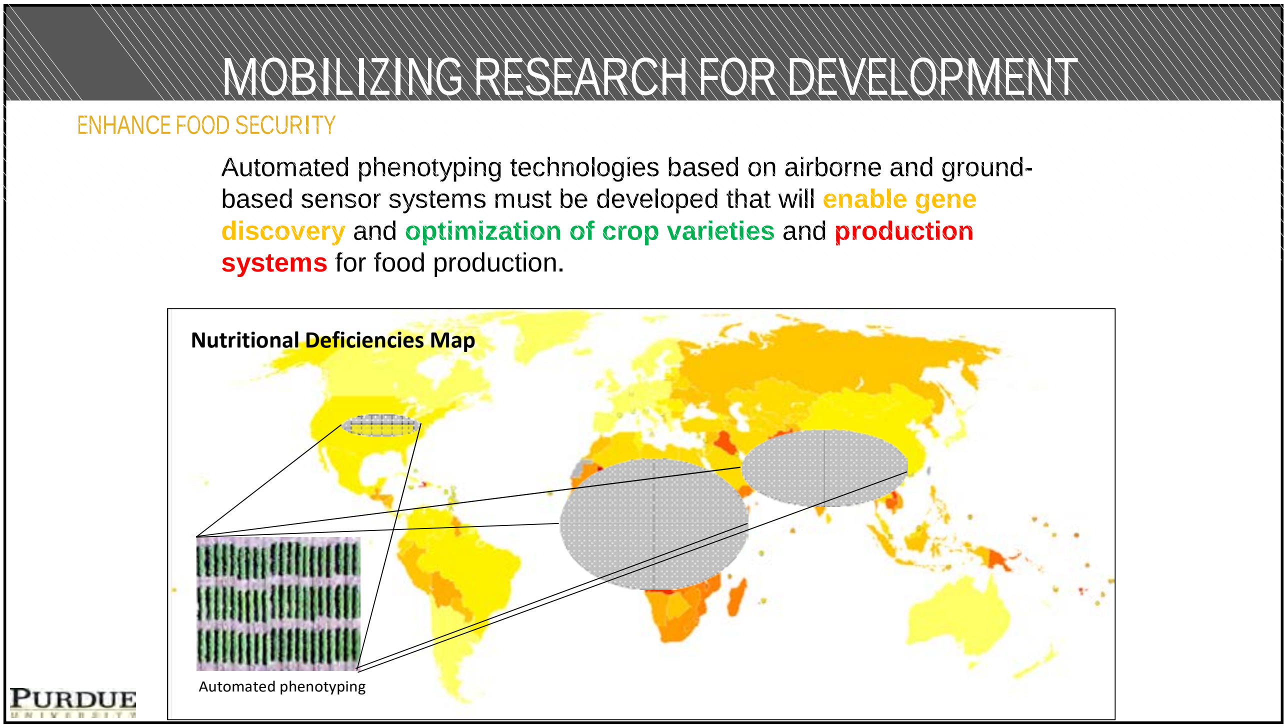
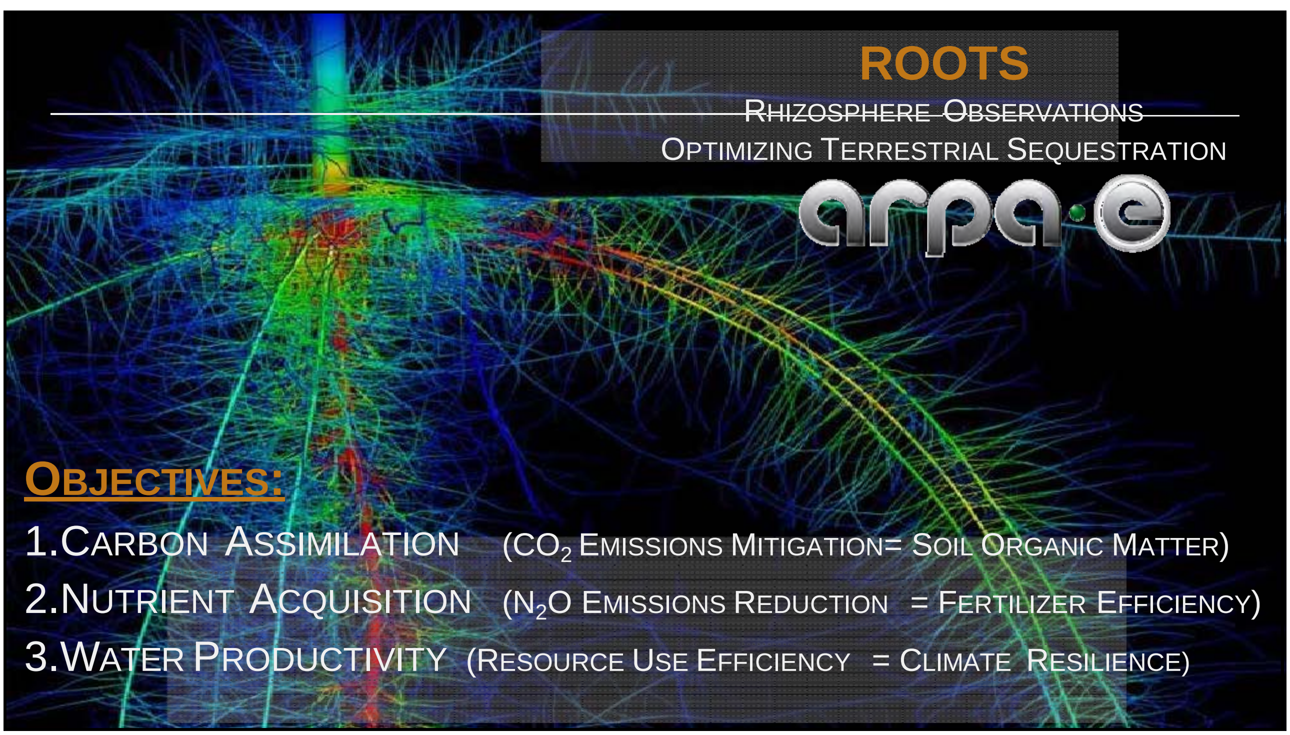

MOBILIZING RESEARCH FOR DEVELOPMENT
ENHANCE FOOD SECURITY
Automated phenotyping technologies based on airborne and ground-based sensor systems must be developed that will enable gene discovery and optimization of crop varieties and production systems for food production.
Nutritional Deficiencies Map
Automated phenotyping
PURDUE
UNIVERSITY


ROOTS
RHIZOSPHERE OBSERVATIONS
OPTIMIZING TERRESTRIAL SEQUESTRATION
arpa·e
OBJECTIVES:
1.CARBON ASSIMILATION (CO2 EMISSIONS MITIGATION= SOIL ORGANIC MATTER)
2.NUTRIENT ACQUISITION (N2O EMISSIONS REDUCTION = FERTILIZER EFFICIENCY)
3.WATER PRODUCTIVITY (RESOURCE USE EFFICIENCY = CLIMATE RESILIENCE)

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4

Laurie-Ann Flanagan

Executive Vice President
D.C. Legislative and Regulatory Services, Inc.

Sara Scherr, Ph.D. moderating

The Role of Biopesticides and Biostimulants in Sustainable Agriculture Systems

Prepared for USDA's Visioning of U.S. Agriculture Systems for Sustainable Production Listening Session

March 2, 2017

bpia

What are Biopesticides?

Biopesticides are reduced risk pesticides that are naturally derived or synthetic equivalents of natural materials such as animals, plants, bacteria, fungi and certain minerals, generally posing little risk to humans or the environment. Biopesticides:

- Allow conventional growers to integrate reduced risk pesticides into their pest management program
- Play an important role in public health protection
- Are important components of IPM Programs
- Allow greater flexibility when harvesting due to short restricted entry intervals
- Are effective resistance management tools because of their alternative modes of actions
- Can be used as residue-management tools
- Allow organic growers to control pests while maintaining their certified status

bpia

What are Biostimulants?

Biostimulants are derived from natural or biological sources such as bacterial or microbial inoculants, biochemical materials, amino acids, humic acids, fulvic acid, seaweed extract and other similar materials. These products improve agricultural sustainability and soil health. Biostimulants:

- Enhance plant growth and development
- Improve the efficiency of plant nutrients, as measured by either improved nutrient uptake or reduced nutrient losses to the environment, or both; and/or
- Act as soil amendments, with demonstrated ability to help improve soil structure, function or performance and thus enhance plant response

bpia

Policies that encourage the development and use of new biopesticide and biostimulant products will enhance the sustainability and productivity of both conventional and organic agriculture over the next several decades

Suggested Policies to Further the Development and Adoption of Biopesticides and Biostimulants

- Increase funding for USDA’s Minor Crop Pest Management (IR-4) Program’s Biopesticide and Organic Support Program and other research programs related to pest control
- Add an input provider’s seat to the National Organic Standards Board
- Clarify the definition of biostimulants and consistently apply that definition across all associated regulatory structures
- Encourage the use of biopesticides and biostimulants in USDA Conservation Programs
- Task the USDA BioPreferred Program and BPIA to develop criteria for certifying biopesticides as USDA BioPreferred

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 # 5

Tom Martin

Chairman & CEO

EnviroCirc

bpia BIOPESTICIDE INDUSTRY ALLIANCE

Tom Martin

CEO

EnviroCirc™

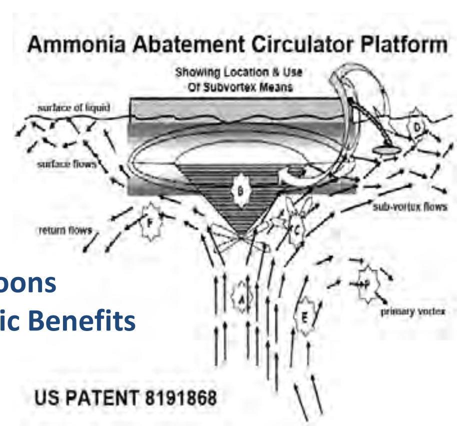
Circular Farm Green Bond

- 3 percent, 20-year, $10B Green Bond
- Save Family Farms – Kids return to farming
  - Fund organic farm transition - Partner with lenders
  - Respected underwriter & 3rd party verification
  - Governed by ICMA Green Bond Principles
  - Tap CERES sustainability-focused fund managers
  - Issuance requires verifiable Enviro-benefits
  - Model delivers *EnviroHealth* improvements, profitably
  - Lake Erie & Lake Champlain Eutrophication solution
  - Circular Farm Agrarian Communities – new paradigm

EnviroCirc™

Proven Via NRCS Field Trials
On 11 Dairy/Swine Farms.
CIG Grant # NRCS 69-3A75-0-123

Aerobic Treatment Of Manure Lagoons
Showing Environmental & Economic Benefits
With Eco-Service System Paybacks



- Makes Manure Disappear
- Transformed to 99% true liquid *EnviroFertilizer™*
- Odor/Pathogen-free SOLUTION enables:
  - Precision *Fertigation* via Pivot, Drip or SDI
  - Cover Crop + No-Till + *EnviroFertilizer™* =
  - Elimination of Chemical Fertilizer
  - Transform farmland to Organic @Scale – Double Value

Circular Farm Organically Fed PORK

Enviro Circ

Vermont Organically Fed DAIRY

Tom Martin - CEO
781-686-2133
EnviroCirc.wordpress.com
Tom@NewVentureStrategies.com

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6

Rebecca A. Dudley

Chairman & CEO
EnviroCirc

DIGITAL APPETITE IN RURAL AMERICA: INNOVATIVE AGRICULTURAL TECHNOLOGIES AND THE POTENTIAL FOR USDA

accenture

The comments and opinions expressed herein are those of individual stakeholders made publicly and do not necessarily represent those of USDA

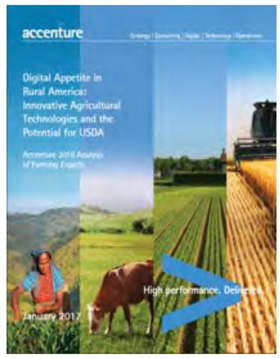
OUR STUDY – DIGITAL APPETITE IN RURAL AMERICA

THE PUBLIC GAZE HAS SHIFTED TOWARDS RURAL AMERICA

What drives rural America?

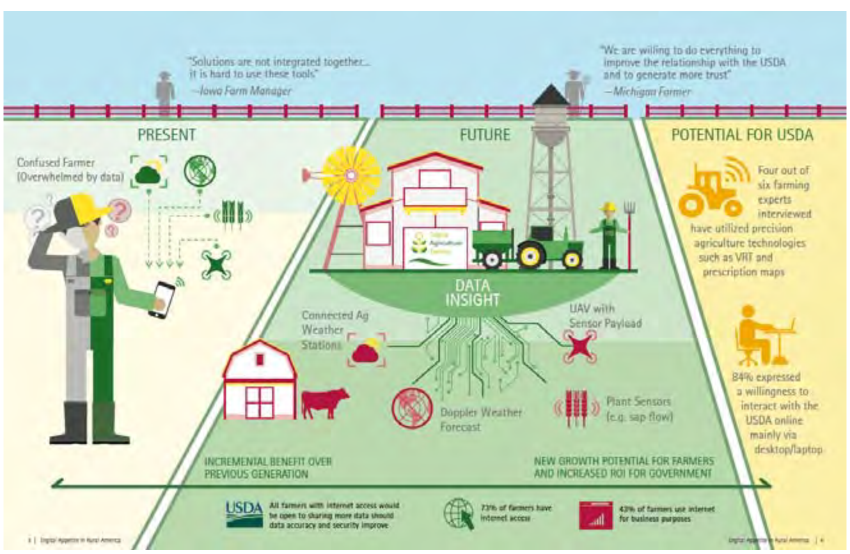
What constrains rural America?

How are new, digital technologies transforming farming decisions and operations?



We talked to farmers across the US – from Oregon, Kansas, Iowa, Michigan, and Kentucky.

They're using key technologies like connected crop services, yield map analysis, droning, and precision irrigation.



70% access high-speed internet.

73% use digital technology in day-to-day decisions.

84% expressed willingness to interact with USDA online.

FARMERS WANT TO ENGAGE, BUT...

The comments and opinions expressed herein are those of individual stakeholders made publicly and do not necessarily represent those of USDA

THEY NEED TO BE **REASSURED** FIRST.

What is the return on investment for engagement in digital?

Why isn't the digital farming experience intuitive and easy?

How can they be sure that their data is secure?

USDA CAN **TAP INTO THIS APPETITE**.

Focus on digital solutions that align to rural sector and farming needs.

Connect data from disparate platforms, and help users connect in.

Build on connected data for insights and enhanced analytics for predictive modeling.

 48

AND HERE'S **HOW:**

Build on existing programs

Rural Development: Building telecommunications

Across USDA: New farming technologies

Create new opportunities

Create digital solutions that connect data sources – from sensors in the field to weather prediction

Enable farmers easy, plug-and-play tools for predictive analytics

CONTACT US

Elaine Turville, Managing Director, Human Services
elaine.k.turville@accenturefederal.com

Danny Cohanpour, Management Consulting Senior Analyst, AFS CleanTech
daniel.cohanpour@accenturefederal.com

Molly Bauch, Technology Strategy Manager, AFS CleanTech
molly.bauch@accenturefederal.com

Rebecca Dudley, Management Consulting Senior Analyst, AFS CleanTech
rebecca.a.dudley@accenturefederal.com

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 # 7

Matthew Lange, PhD

Research Food and Health Informatician
Principal Investigator, IC3-FOODS
Associate Director, Initiative for Wireless Health & Wellness
UC Davis and UC Davis Health System

Semantic Web & Internet of Food
Food Systems, Food, Eating, Drinking, & Health

Enabling Decision support for:

Food Production, Processing, Safety, Security
Environmental Sustainability
Personalized Products
Wellness & Happiness

@mateolan Matthew Lange, PhD mclange@ucdavis.edu

IC3-FOODS:
International Conference - Consortium - Center for
Food Ontology Operability Data and Semantics

Semantic Web & Internet of Food

A common language, infrastructure, & pre-competitive platform to operationalize vast data along:

Env⇔Ag⇔Food⇔Diet⇔Health

CITRIS | UC DAVIS INNOVATION INSTITUTE FOR FOOD AND HEALTH | UC DAVIS CIFAR | UC DAVIS AGRICULTURAL SUSTAINABILITY INSTITUTE

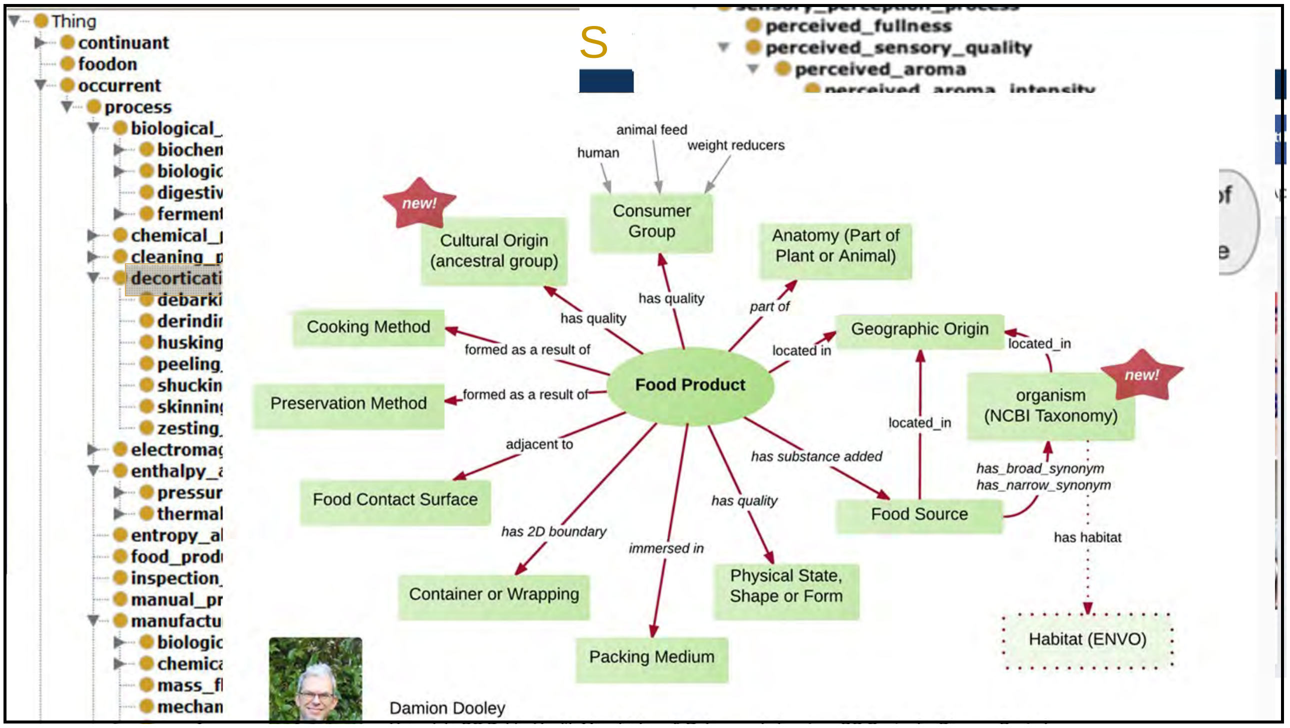
@IC3FOODS **www.ic-foods.org** **#InternetOfFood**

@IC3FOODS ASSEMBLING-DESIGNING-BUILDING THE ONTOLOGICAL AND COMPUTATIONAL INFRASTRUCTURE FOR *The Internet of Food*

IC3-FOODS:
International Conference - Consortium - Center for
Food Ontology Operability Data and Semantics

Pervasive sensors: window into human behavior

@IC3FOODS ASSEMBLING-DESIGNING-BUILDING THE ONTOLOGICAL AND COMPUTATIONAL INFRASTRUCTURE FOR *The Internet of Food*


Thing
continuant
foodon
occurrent
process
perceived_fullness
perceived_sensory_quality
perceived_aroma
animal feed
human
weight reducers
Consumer Group
new!
Cultural Origin (ancestral group)
Anatomy (Part of Plant or Animal)
has quality
has quality
part of
Cooking Method
formed as a result of
Geographic Origin
located in
located_in
Food Product
Preservation Method
formed as a result of
new!
organism (NCBI Taxonomy)
located_in
adjacent to
has substance added
has_broad_synonym
has_narrow_synonym
Food Contact Surface
has quality
Food Source
has 2D boundary
has habitat
immersed in
Container or Wrapping
Physical State, Shape or Form
Habitat (ENVO)
Packing Medium
Damion Dooley


IC3-FOODS
International Conference - Consortium - Center for Food Ontology Operability Data & Semantics
IC-FOODS@ Seeds & Chips
THE GLOBAL FOOD INNOVATION SUMMIT
SEEDS & CHIPS
WE BRING FOOD & TECHNOLOGY TOGETHER, FROM FARM TO FORK AND BEYOND
MAY 8-11, 2017 / MILANO, ITALY
ASSEMBLING-DESIGNING-BUILDING THE ONTOLOGICAL AND COMPUTATIONAL INFRASTRUCTURE FOR
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USDA United States Department of Agriculture | Office of the Chief Scientist

Visioning of United States, (U.S.) Agricultural Systems for Sustainable Production Stakeholder Listening Session Meeting

Thursday, March 2, 2017 8:30am – 4:30pm USDA South Building Cafeteria

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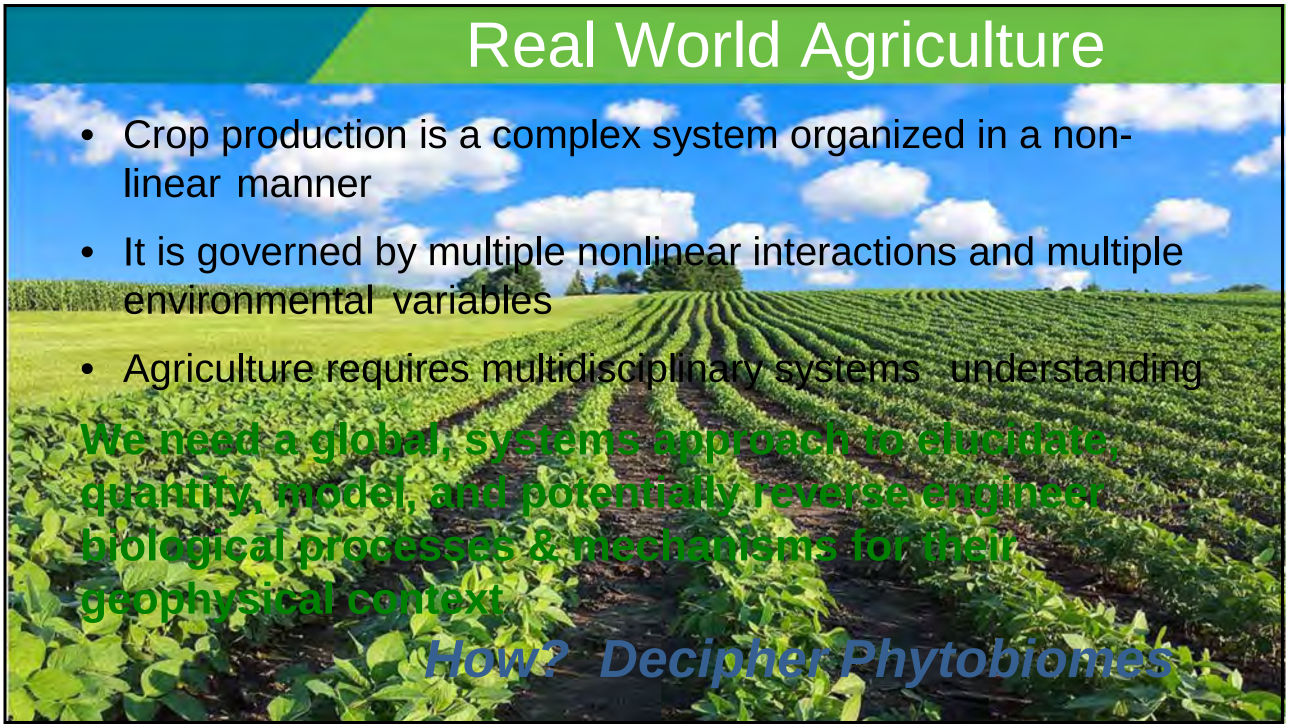
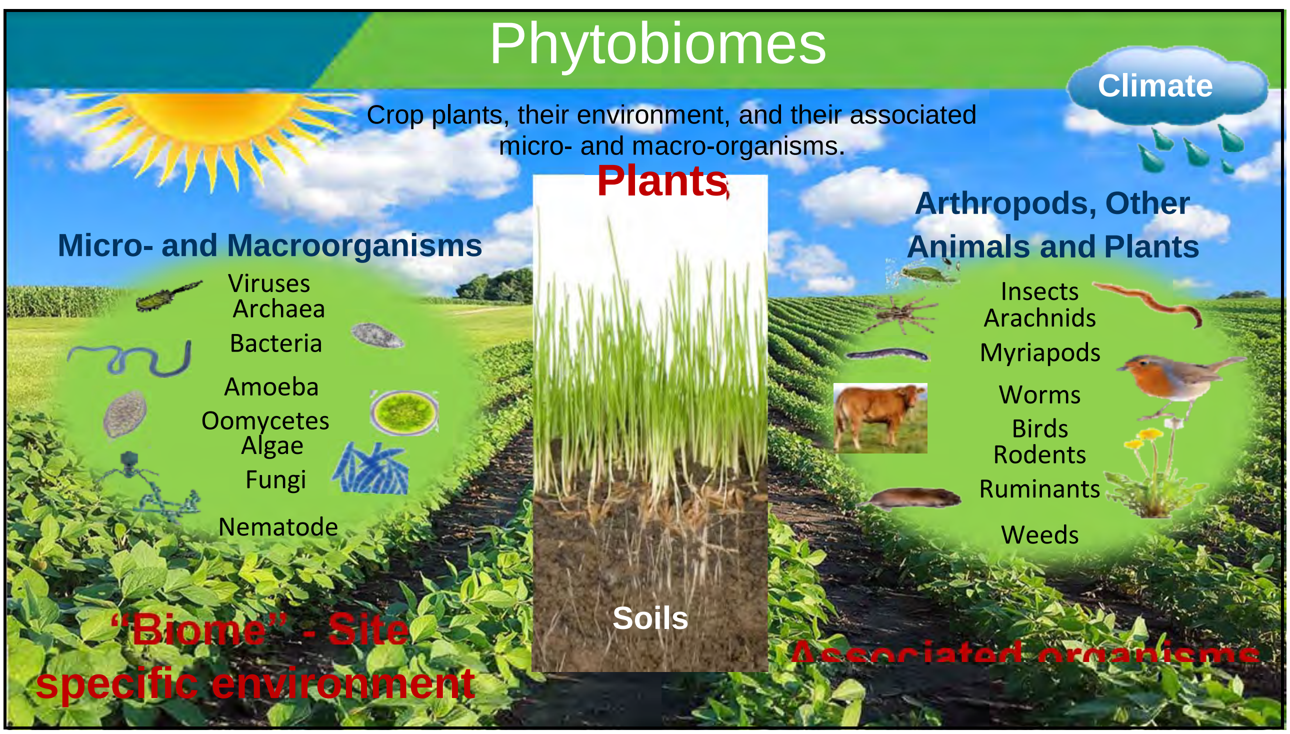
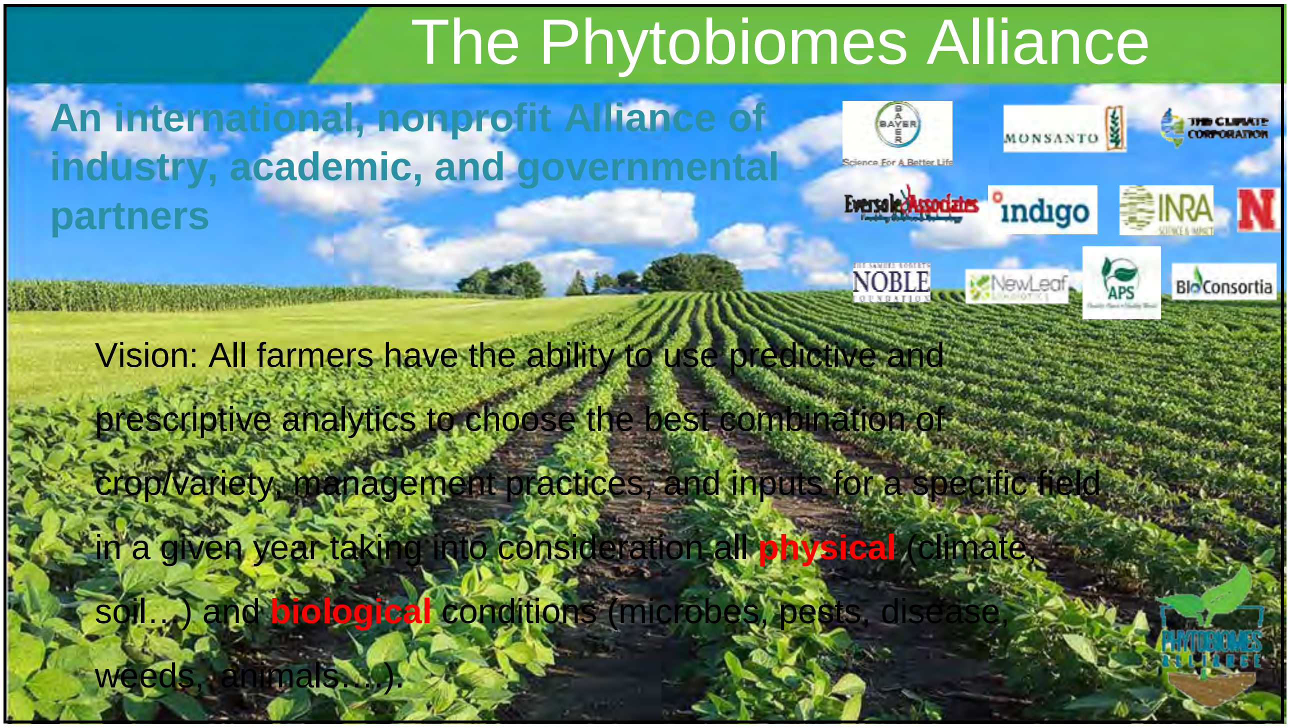
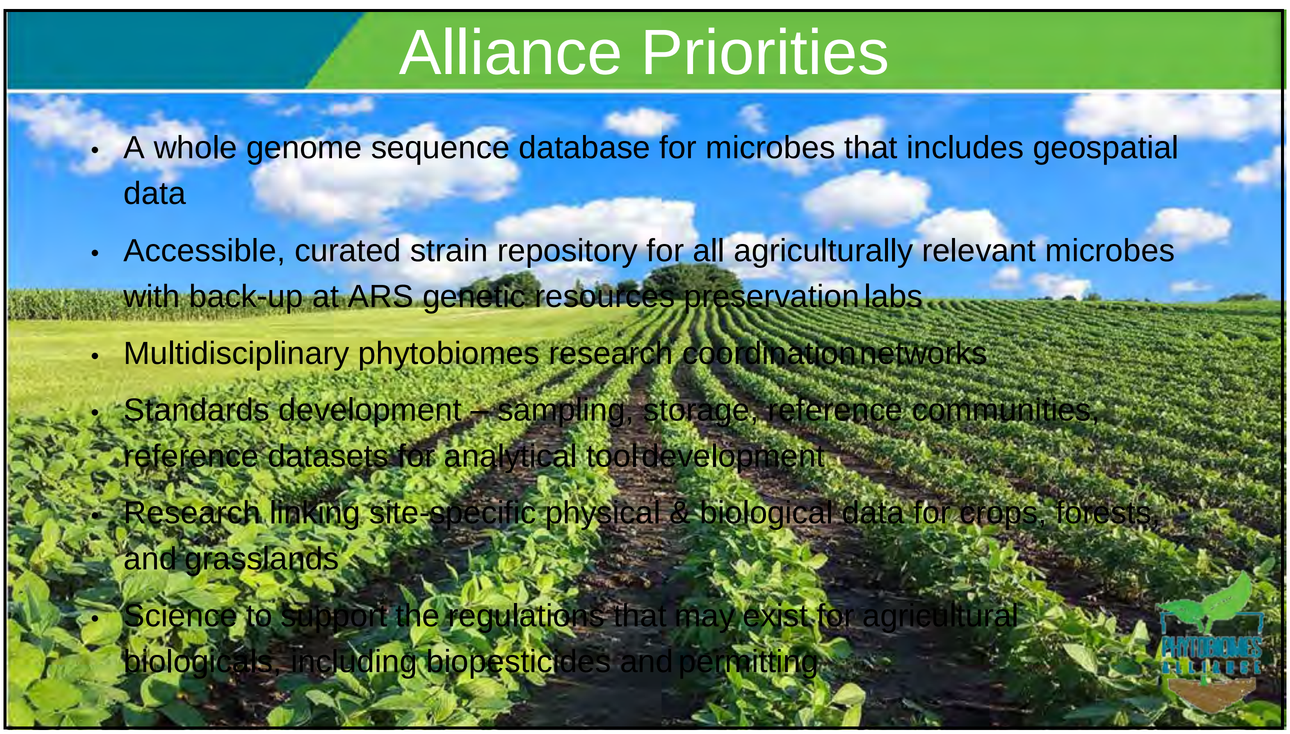
Kristina J. Owens

Scientific Advisor & Associate
Eversole Associates


Real World Agriculture
• Crop production is a complex system organized in a non-linear manner
• It is governed by multiple nonlinear interactions and multiple environmental variables
• Agriculture requires multidisciplinary systems understanding
We need a global, systems approach to elucidate, quantify, model, and potentially reverse engineer biological processes & mechanisms for their geophysical context
How? Decipher Phytobiomes


Phytobiomes
Climate
Crop plants, their environment, and their associated micro- and macro-organisms.
Plants
Micro- and Macroorganisms
Viruses
Archaea
Bacteria
Amoeba
Oomycetes
Algae
Fungi
Nematode
Arthropods, Other Animals and Plants
Insects
Arachnids
Myriapods
Worms
Birds
Rodents
Ruminants
Weeds
Soils
"Biome" - Site specific environment


The Phytobiomes Alliance
An international, nonprofit Alliance of industry, academic, and governmental partners
BAYER
Science For A Better Life
MONSANTO
THE CLIMATE CORPORATION
Eversole Associates
indigo
INRA
N
NOBLE
NewLeaf
APS
BioConsortia
Vision: All farmers have the ability to use predictive and prescriptive analytics to choose the best combination of crop/variety, management practices, and inputs for a specific field in a given year taking into consideration all physical (climate, soil...) and biological conditions (microbes, pests, disease, weeds, animals....).
PHYTOBIOMES ALLIANCE


Alliance Priorities
• A whole genome sequence database for microbes that includes geospatial data
• Accessible, curated strain repository for all agriculturally relevant microbes with back-up at ARS genetic resources preservation labs
• Multidisciplinary phytobiomes research coordination networks
• Standards development – sampling, storage, reference communities, reference datasets for analytical tool development
• Research linking site-specific physical & biological data for crops, forests, and grasslands
• Science to support the regulations that may exist for agricultural biologicals, including biopesticides and permitting
PHYTOBIOMES ALLIANCE

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Sara Scherr, Ph.D.

Moderated Questions and Discussion Time

Laurie Flanagan

Tom Martin

Rebecca Dudley

Matthew Lange

Kristina J. Owens

reminder: if no live comments, go to WebEx chat

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20min Break and Networking

reminder: stop and restart WebEx Recording to reduce file size