Robotics & AI for Sustainable & Equitable Agricultural Systems

USDA 100th Annual Agricultural Outlook Forum

Panelists

- John Shutske, University of Wisconsin-Madison (moderator)
- Madhu Khanna, Professor and Distinguished Professor in Environmental Economics, University of Illinois
- Ethan Rublee, Founder & CEO farm-ng
- Danielle Boyer, Indigenous (Ojibwe) Robotics Inventor and Youth Advocate – unable to join today




Introduction – Examples of Agricultural Robotics and Other Forms of Automation

- By application
  - Plant production
  - Animal production
  - Environmental applications (monitoring, product application)
- By size and scale
  - Full-size autonomous or highly automated
  - Mid-small size
  - Robots working in fleets or “swarms”

  - Robots for integrated systems and uses (cover cropping, scouting, other)
  - UAV (“drone”) applications

Helper Robots

Animal Care (feeding, milking)

Traditional OEM Field Application

Field/Orchard Application

Driving Forces

- Labor supply
- Desirability of traditional work in agriculture
  - 3D's – agricultural work traditionally viewed as "dull, dirty, and dangerous"
- Economics
- Leveraging data – enabled by increasingly accessible tools (AI, ML, etc.) for:
  - Natural resource use and protection
  - Worker and public safety
  - Maximizing resource efficiency

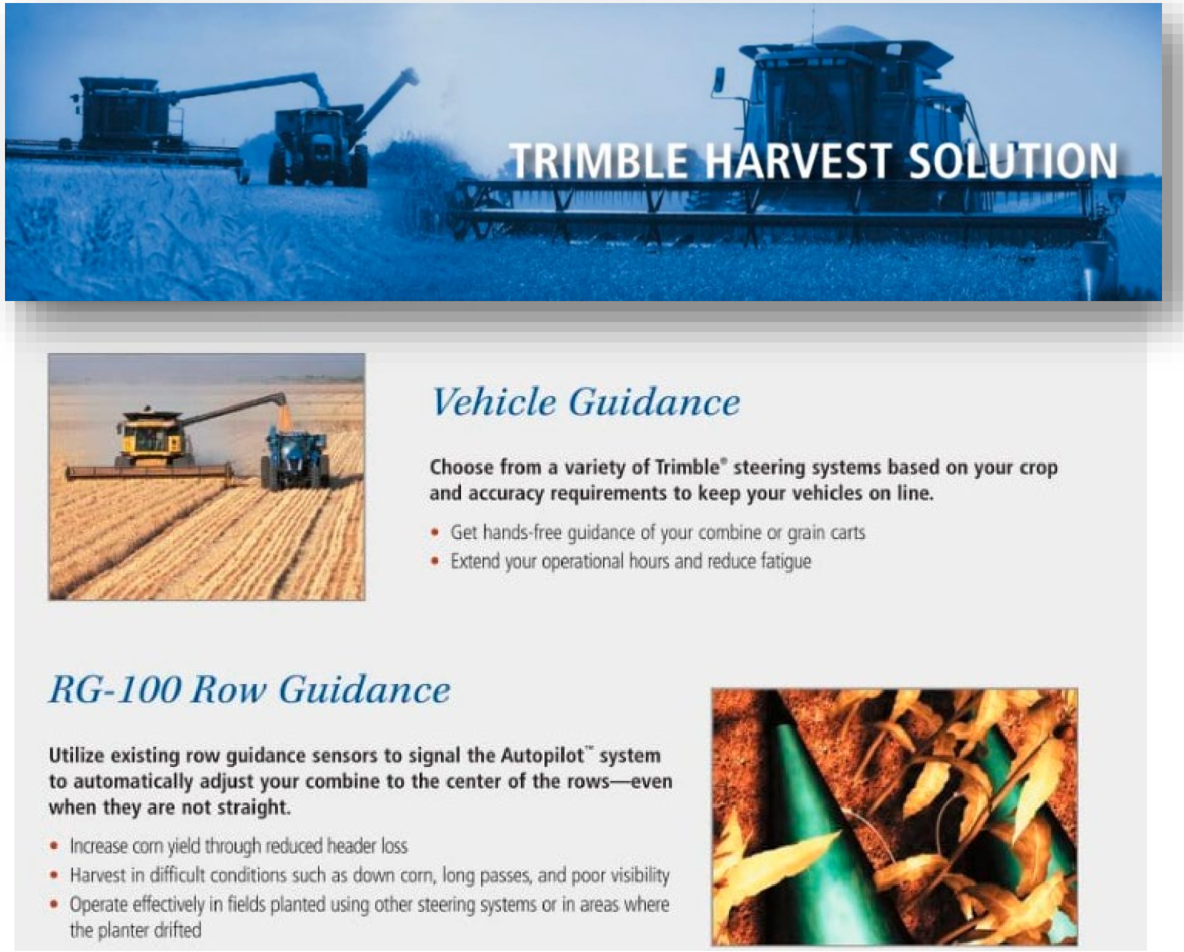
Transition from Horses to Mechanization

- Number of tractors > horses in 1954 (U.S.)
- This transition began in the late 1800s
- Seemingly glacial – steam engines, internal combustion, steel wheels, rubber tires
- Lots of pushback, many naysayers
- “Big” revolutions (mid 1900s) – PTO, hydraulics, safety devices, comfort cabs

Original art by W.H. Hinton (1886-1980). Initially published as a John Deere tractor ad – 1936. Published in This Old Tractor and John Deere Journal.

We Are Now in a Similar Transition Time

- Simple monitors (70s and 80s)
- GPS – yield, mapping, precision application (1990s)
- Auto steer & other features
- Self-diagnostics, text alerts, direct machine-to-service communications
- Machine-to-machine communication
- Autonomy, robotics



My Research Focus: Safety & Risk Assessment

- Agriculture = Most dangerous U.S. industry
- Opportunity to improve safety (remove human from hazard)
- Technology for environmental sustainability
- But – Uncertainty on other risk (bystanders, public, service/repair, risk of downtime, possible environmental risk)
- Risk “unknowns” impacting industry through regulation
- Develop new methods that can “foresee risk” (modeling, learning from past, AI and ML, developing exposure databases)

Thanks to USDA-NIFA and the UW-Madison Agricultural Experiment Station

Contact Information

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- https://bse.wisc.edu/staff/shutske-john/


A-ASH-FS-103 (2023)

Agricultural Autonomy, Technology & the Future

Agricultural Safety & Health Program

What Can YOU Do Today?

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Key Points

- Labor concerns are pushing the development of robots and highly-automated agricultural machine systems
- You can start by being a great employer TODAY! Adopting technology requires worker involvement, trust, and buy-in to be successful
- We should continue to push for robust and affordable high speed Internet in all farming areas—this includes mobile access
- Go into purchase decisions eyes wide open—Ask lots of questions and carefully examine the validity of financial claims and information as they relate to YOUR operation
- Take your time. Learn from others. Travel and attend demos and ask adopters about their experiences

The Agricultural Safety & Health program is in the the Biological Systems Engineering Department at UW-Madison. For more information, check out agsafety.wisc.edu

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Artificial Intelligence for Future Agricultural Resilience, Management, and Sustainability

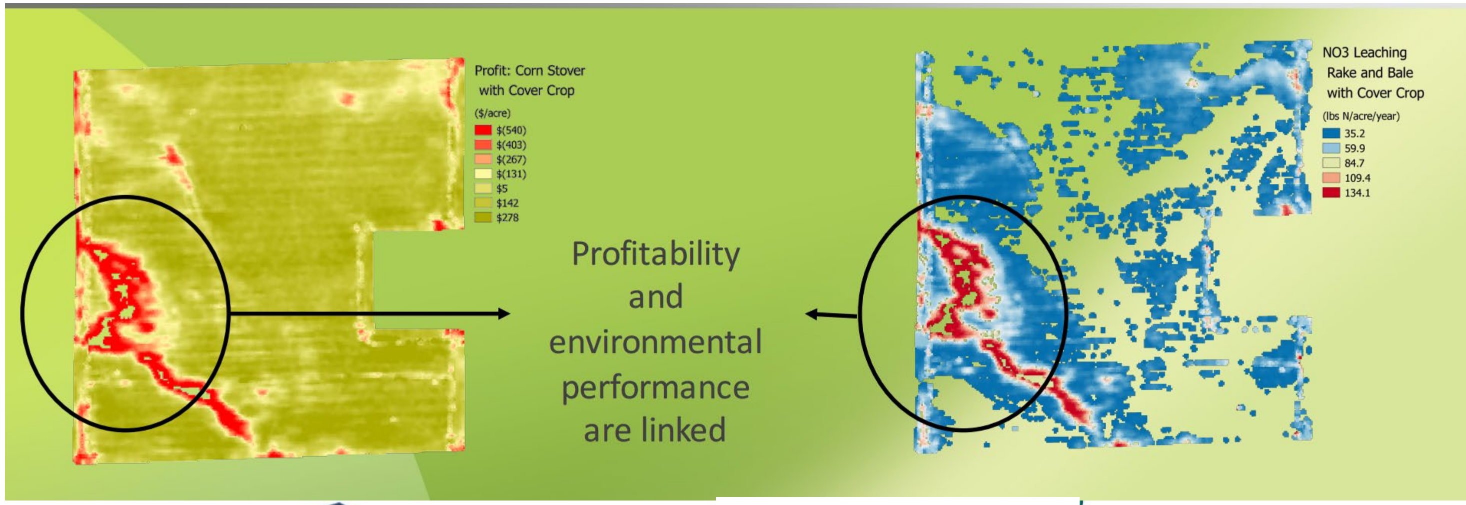
Robotics and AI for Sustainable, Equitable Agricultural Systems

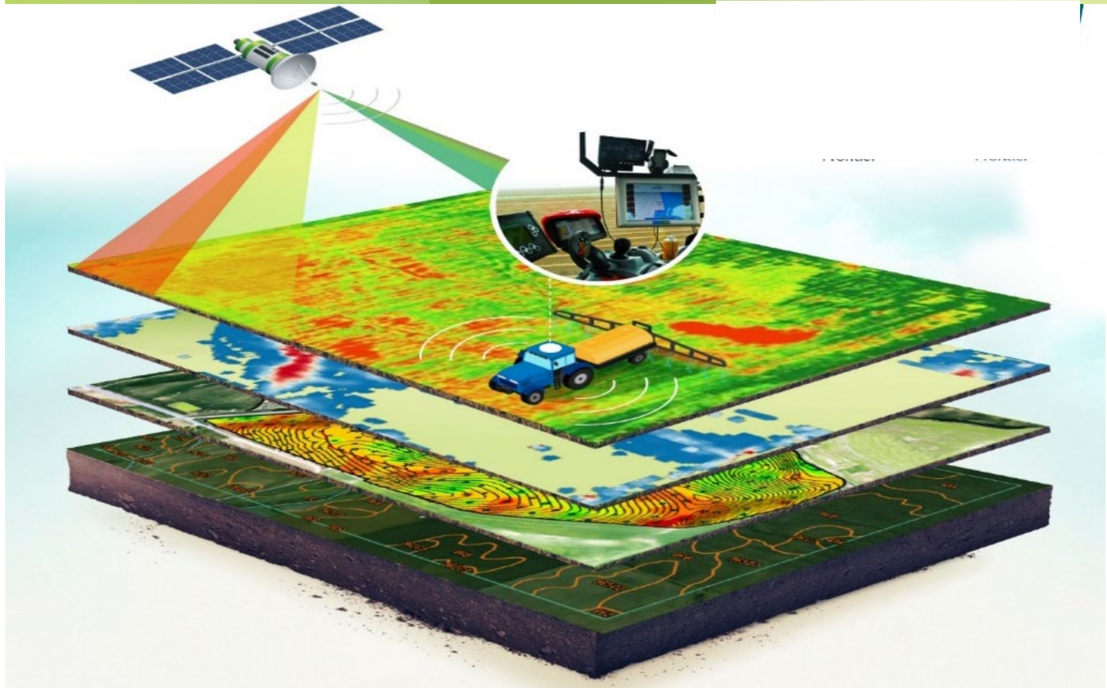
Madhu Khanna
Alvin H. Baum Family Chair and Director, Institute for Sustainability, Energy and Environment
ACES Distinguished Professor of Environmental Economics
University of Illinois

Center for Digital Agriculture

USDA National Institute of Food and Agriculture
U.S. DEPARTMENT OF AGRICULTURE

Grand Challenges for Agriculture





- Increasing crop productivity while reducing environmental harm
- Substantial heterogeneity in growing conditions within and across fields
- Need for data analytics to enable decision making using "big data" generated by precision technologies
- Shortage of labor
  - autonomous systems that can implement complex decisions with precision and timeliness.
- Crop health monitoring, disease detection
  - Growing resistance to pesticides

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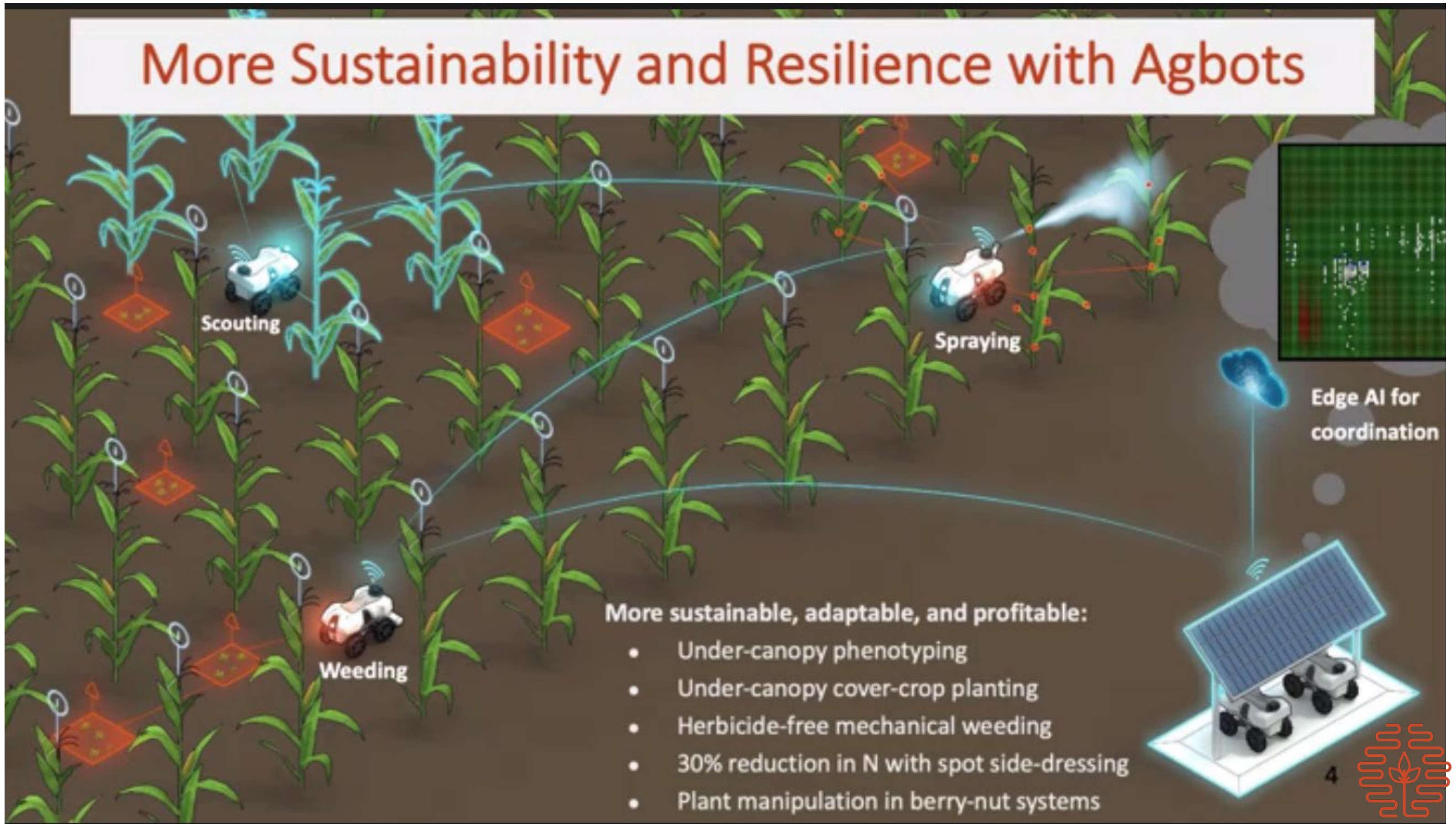
Future of Farming: Artificial Intelligence

- Three key features:
- Gather high resolution data on plant and growing conditions
- Autonomy and robotics to make site specific interventions on the field during the growing season
- Machine learning to improve predictive power for making recommendations that can progressively get more accurate over time by learning from the data and experimentation

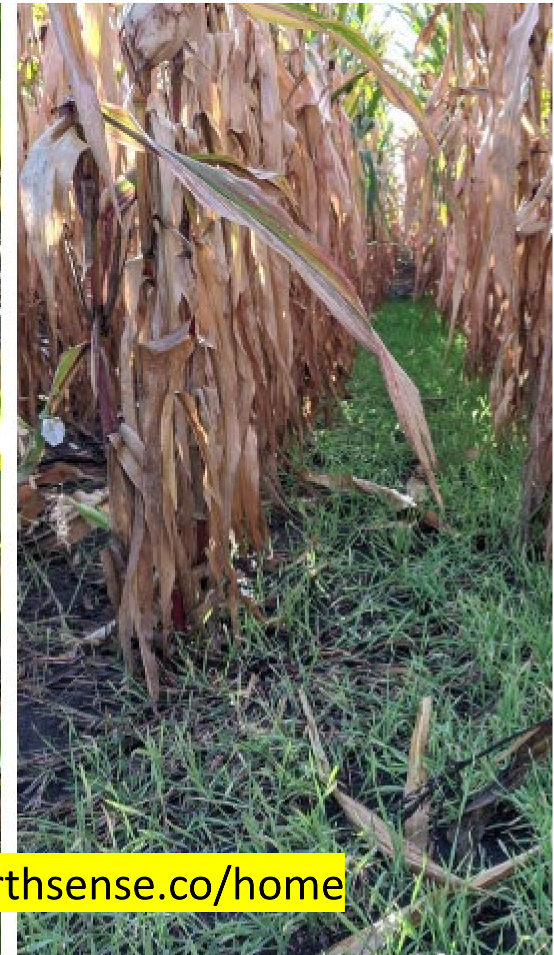


Robotic Weed Management

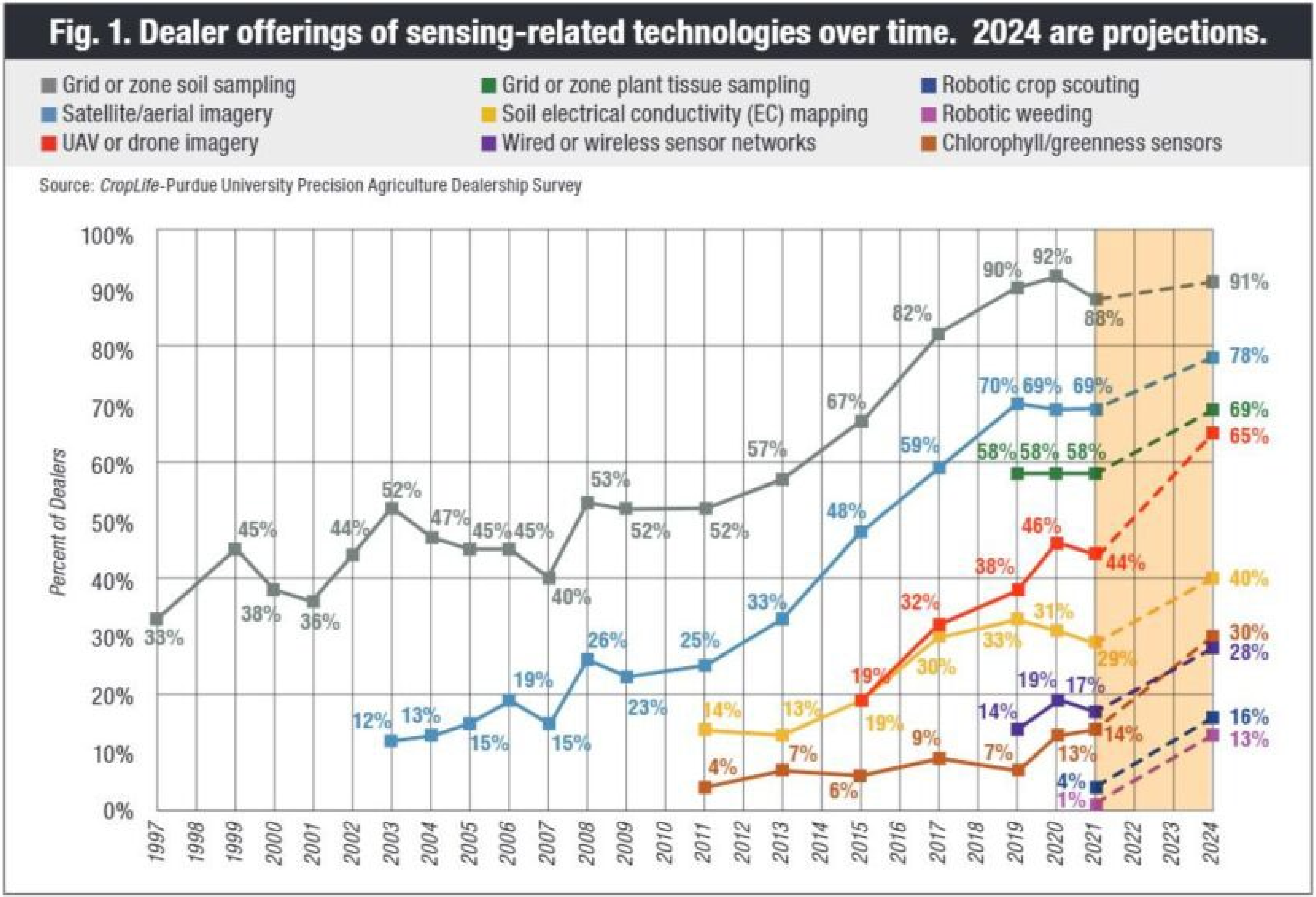
- Conventional herbicides applied before plant canopy closes in early stage of growing season
- Small robots can drive under plant canopy, detect and mechanically remove weeds
- Robots have
  - High weeding efficiency
  - Can work long hours
  - Reduce need for labor; depending on level of autonomy
  - Small size: do not cause soil compaction
  - Reduce need for tillage and increase soil organic matter
  - Delay/avoid weed resistance

Cover Crop Planting Robots

- Under the canopy robots can plant cover crop early in the season to improve establishment with low labor needs
- Ensure grazing cover after harvest and enable diversified and integrated agriculture
- Increase soil health, reduce need for fertilizer, weeds



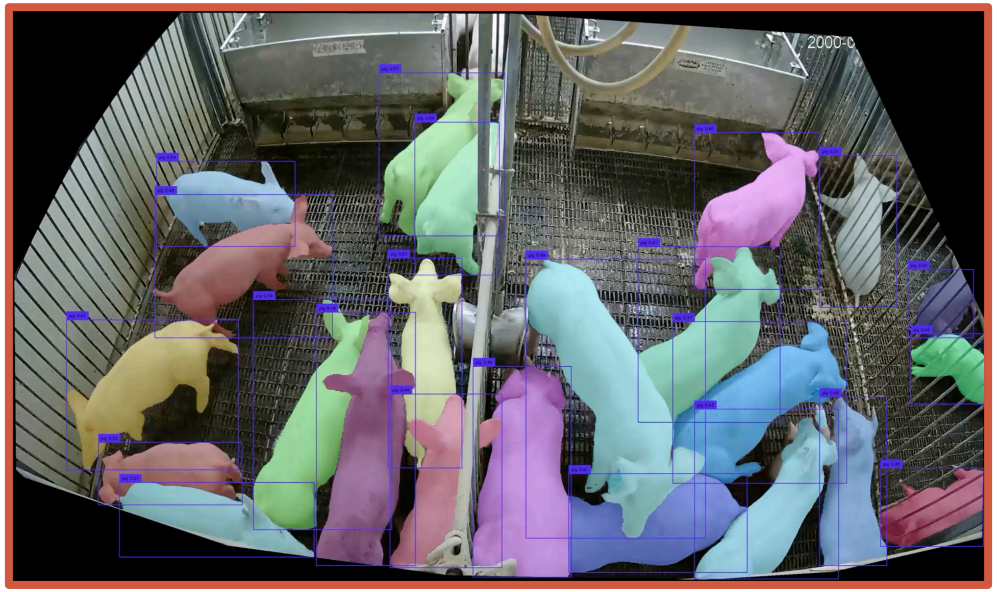
https://www.earthsense.co/home

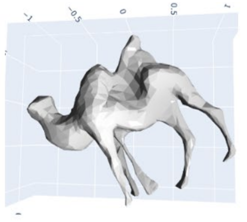


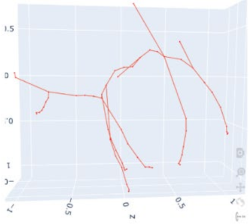
2021 **Precision Agriculture Dealership Survey**

https://www.croplife.com/?s=Precision+Agriculture+Dealership+Survey

Using AI to Reduce and Optimize Labor for Livestock Production







Computer Vision to Support Labor Needs in Commercial Animal Production Systems

- “Eyes” on animals more of the time
- Early identification of animal care needs
    - Illness
    - Lameness
    - Thermal challenges
    - Facility maintenance needs
- Predicting status
    - Estrus
    - Parturition
- Tracking animal growth and development
    - Nutritional needs
    - Market timing

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Likely Drivers of Adoption of AI Technologies by Farmers

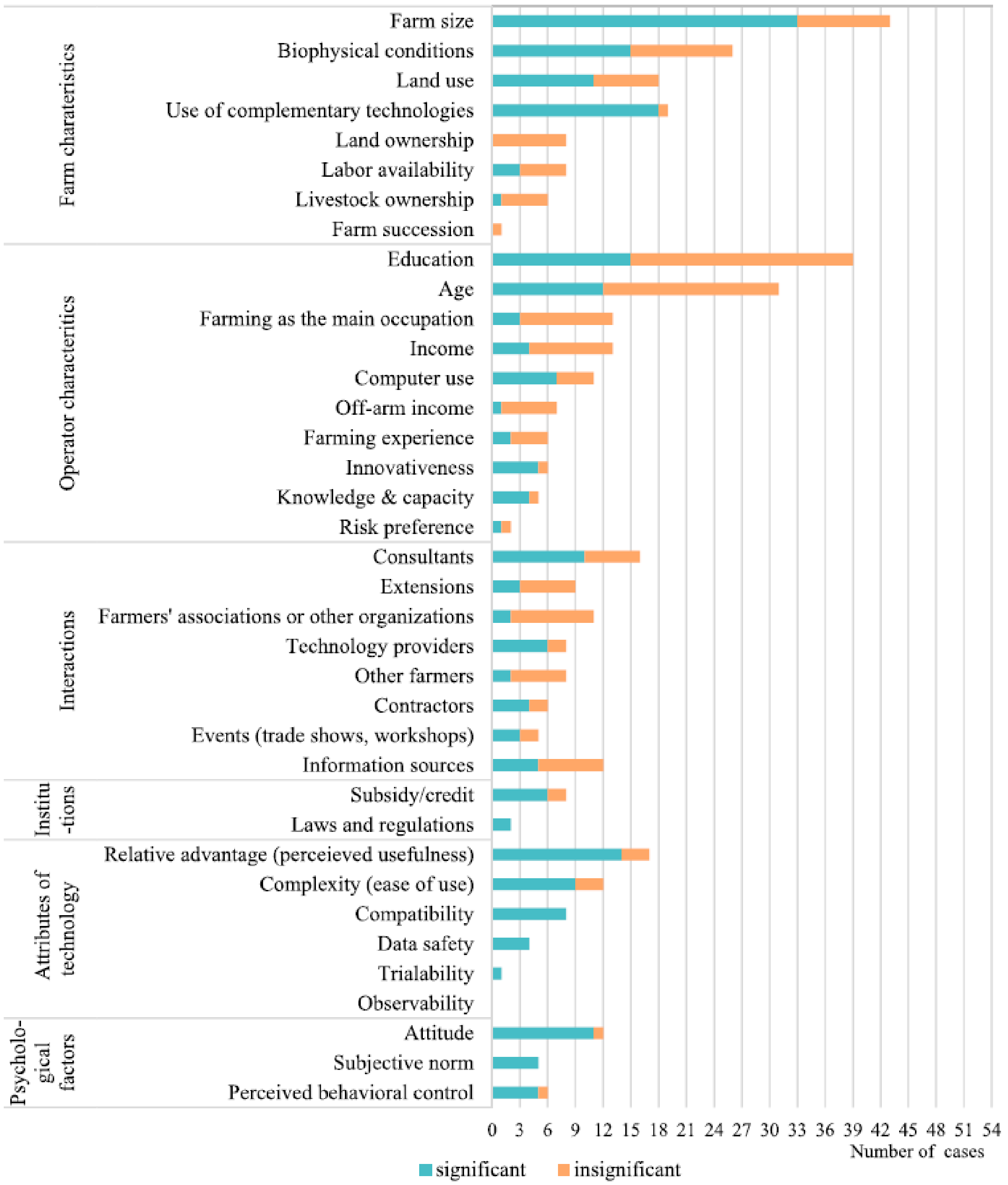

Fig. 1. Influencing factors on farmers' technology adoption decision synthesized from 54 cases. (Source: own results)

Shang et al., 2020

- Higher farm size
- Higher quality land
- Use of complementary technologies, computers
- Availability of skilled labor
- Relative advantage and perceived usefulness
- Education
- Attitudes
- Norms/peer pressure

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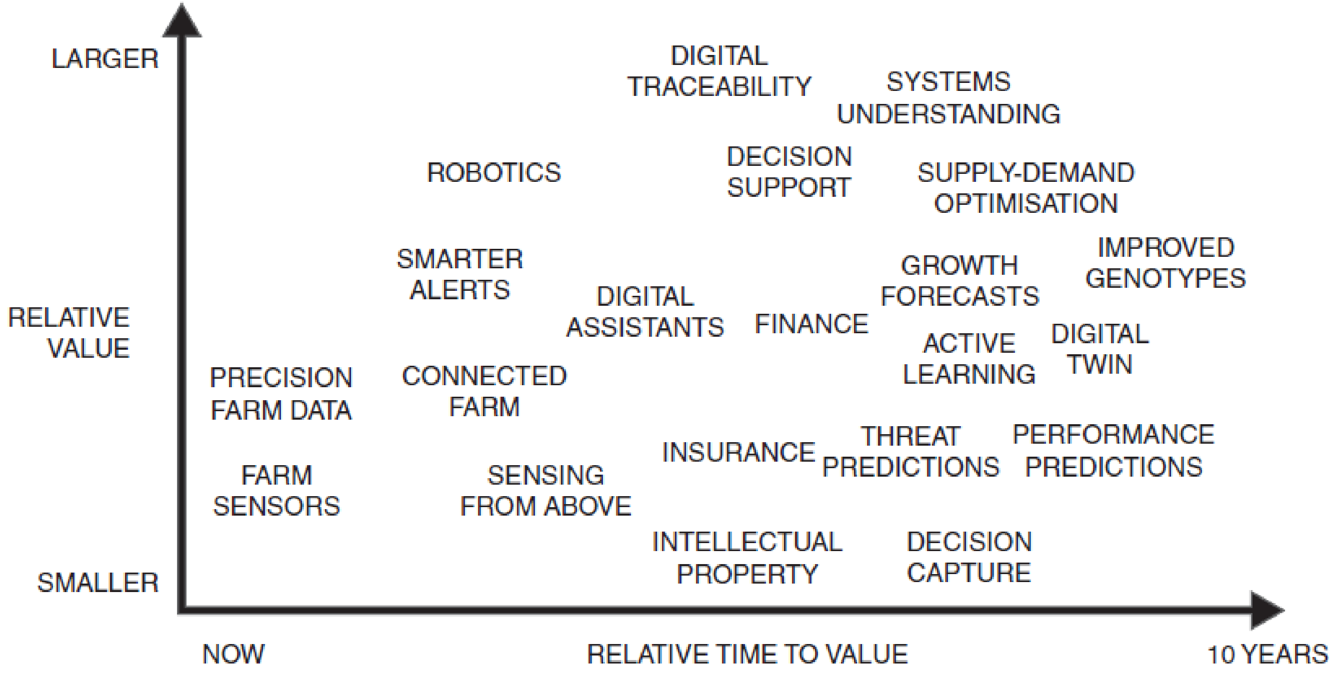
Potential Barriers to Adoption of AI Technologies

- Demonstrated ability to improve farming outcomes
- Data confidentiality, ownership and governance
- Loss of farmer control on farm management decisions
- High speed internet connectivity and access to computers
- Access to technical assistance
- Rapidly developing technologies, interoperability of components

AGRICULTURE 4.0: THE FOURTH REVOLUTION

Artificial intelligence-enabled capabilities that will bring value to agriculture over the next decade



Smith, 2020.

- Potential to transform farm operations
  - Reduce need for human decision making, uncertainty
  - Improve predictability, farm efficiency and health
- Use of digital twins- to better understand functioning of the farm and effect of interventions
- Enable supply-chain traceability

Thanks!

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https://aifarms.illinois.edu/

https://i-farm.illinois.edu/

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University of Illinois, Urbana-Champaign

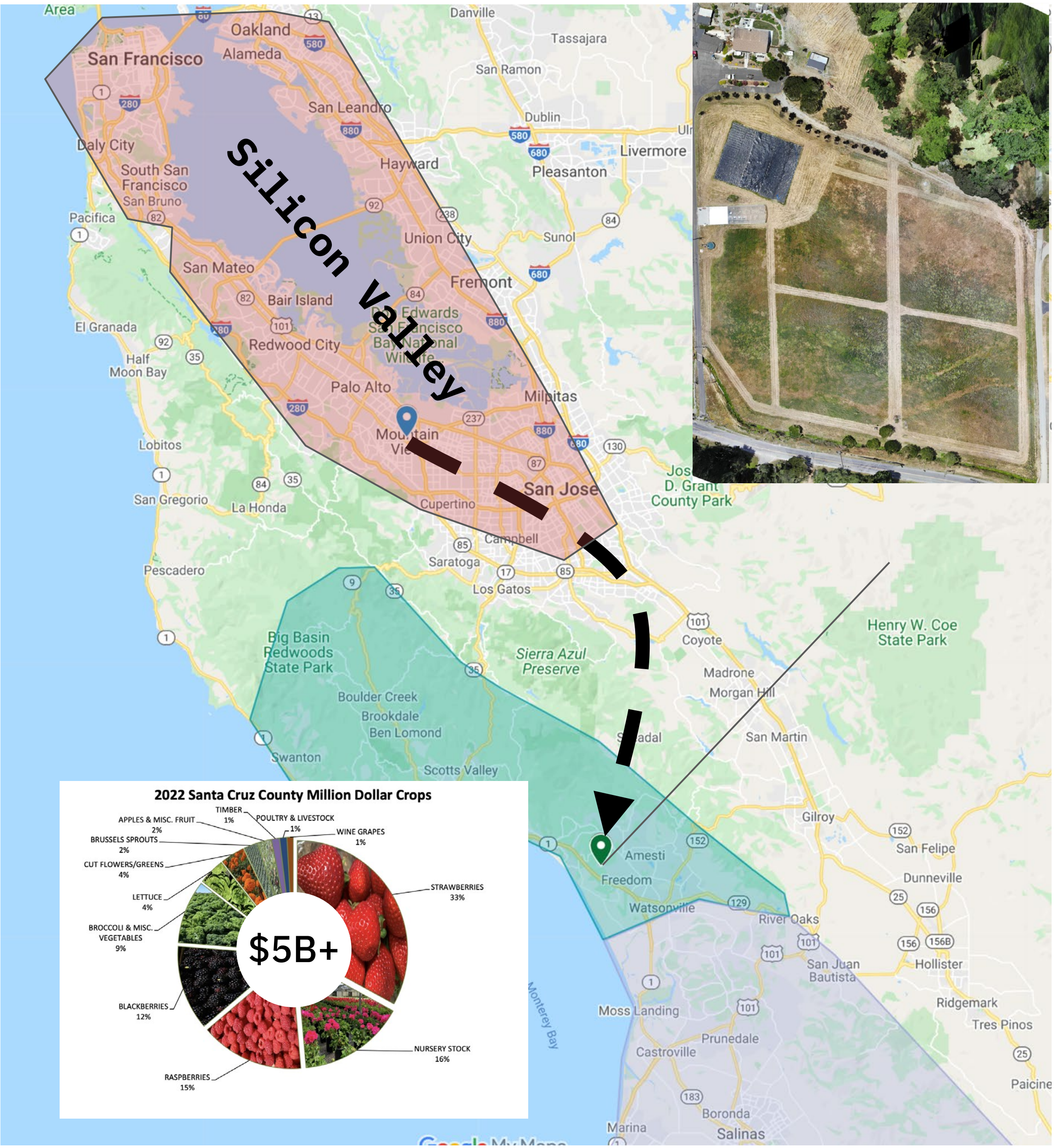
Robotics and AI for Sustainable, Equitable Agricultural Systems

Framing Platform and Workforce Development

- A decade in Silicon Valley
- Founding an Ag Tech Startup
- Farm-ng and the Amiga
- Collaborative innovation

Ethan Rublee


Auto Snapping enabled.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Palo Alto
Milpitas
San Jose
Cupertino
Campbell
Saratoga
Los Gatos
Danville
Tassajara
San Ramon
Dublin
Livermore
Pleasanton
Sunol
El Granada
Half Moon Bay
Lobitos
San Gregorio
La Honda
Pescadero
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Boulder Creek
Brookdale
Ben Lomond
Swanton
Scotts Valley
Sierra Azul Preserve
Coyote
Madrone
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Dunneville
Amesti
Freedom
Watsonville
River Oaks
San Juan Bautista
Hollister
Ridgemark
Tres Pinos
Paicine
Moss Landing
Prunedale
Castroville
Boronda
Salinas
Marina
Monterey Bay
2022 Santa Cruz County Million Dollar Crops
TIMBER 1%
POULTRY & LIVESTOCK 1%
APPLES & MISC. FRUIT 2%
WINE GRAPES 1%
BRUSSELS SPROUTS 2%
CUT FLOWERS/GREENS 4%
STRAWBERRIES 33%
LETTUCE 4%
BROCCOLI & MISC. VEGETABLES 9%
BLACKBERRIES 12%
NURSERY STOCK 16%
RASPBERRIES 15%
$5B+

EatLocal.farm

Started April 1st, 2020:

- Online farmers market, food hub
- 250 boxes / week
- 40+ farms, whole diet
- $750K+ gross over two seasons

farm-ng

Modular robots for every acre

USDA Agricultural Outlook Forum 2024

Amiga

An electric robotic tractor.

Battery powered, light-weight, software defined vehicles will transform agricultural practices.

open source

Right To Repair

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est. 2020

Venture Backed:

$16m Raised to Date

JACOBS FARM DEL CABO CERTIFIED ORGANIC · XPLORER CAPITAL · ACRE

Ethan Rublee | CEO

Cofounder, Industrial Perception *(Acq. $GOOGL)*

Cofounder, Arraiy *(Acq. $MTTR)*

Willow Garage · ipi · ARRAIY

Claire Delaunay | CTO

VP of Engineering, Nvidia

VP of Engineering, Uber

Cofounder, Otto *(Acq. $Uber)*

OTTO · Uber · NVIDIA

30+ People
Manufacturing, Engineering,
Sales, & Farmers

150 Robots Produced

70 Customers

Farmers, Research, Education


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AFFINITY
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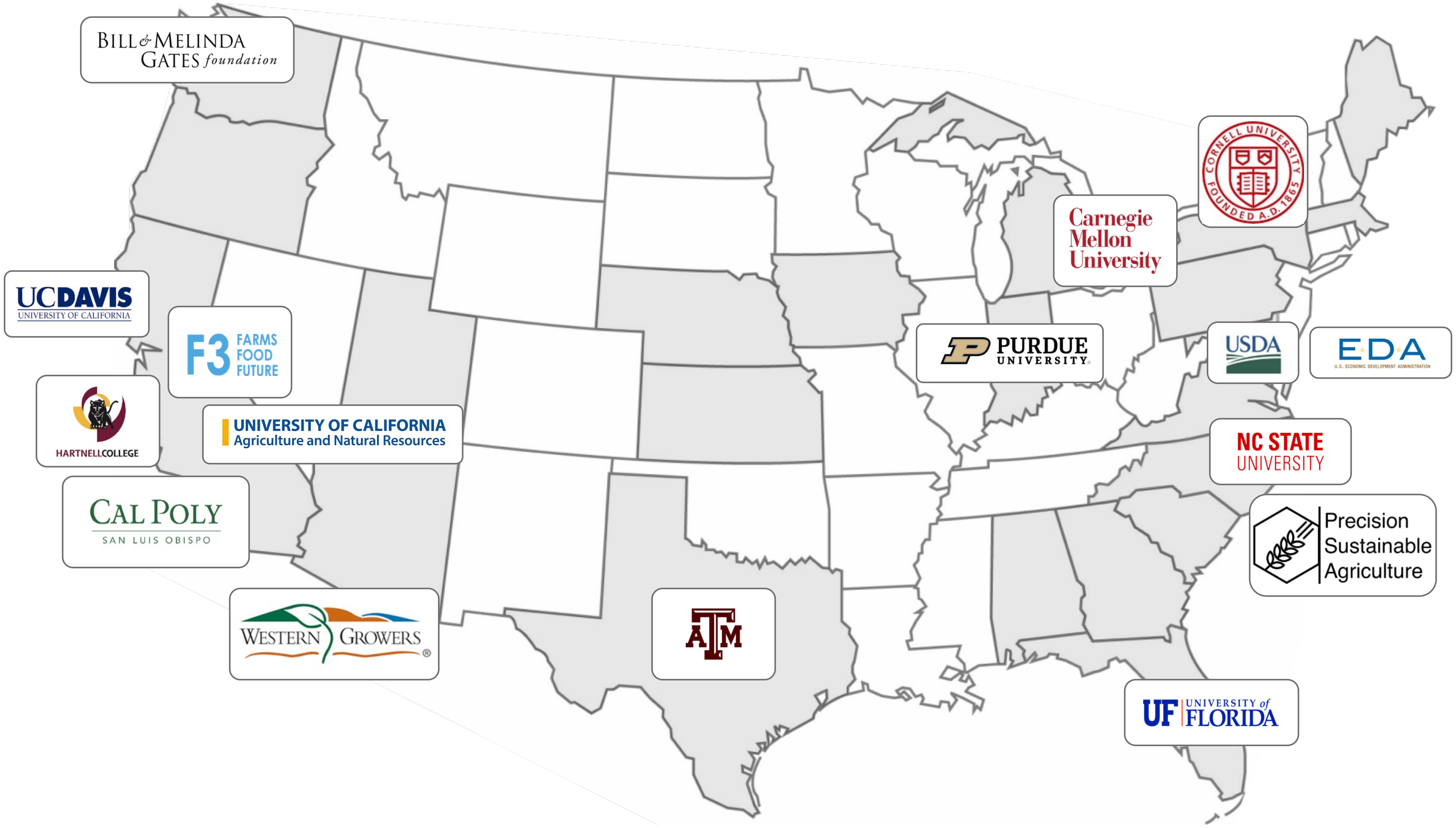
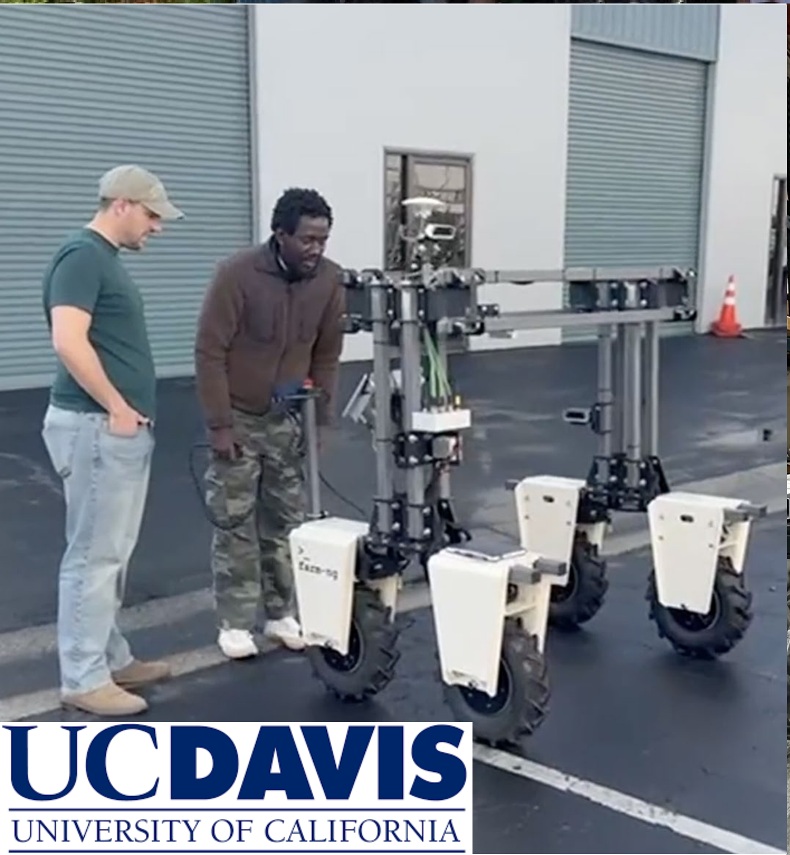
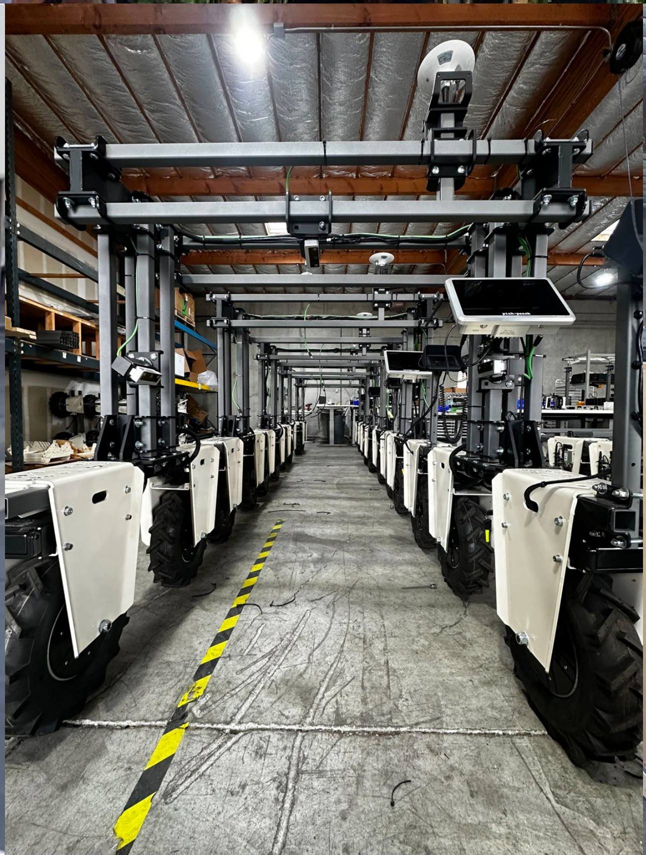
Broad adoption across research and education in agriculture.



GEMINI

BILL & MELINDA GATES foundation





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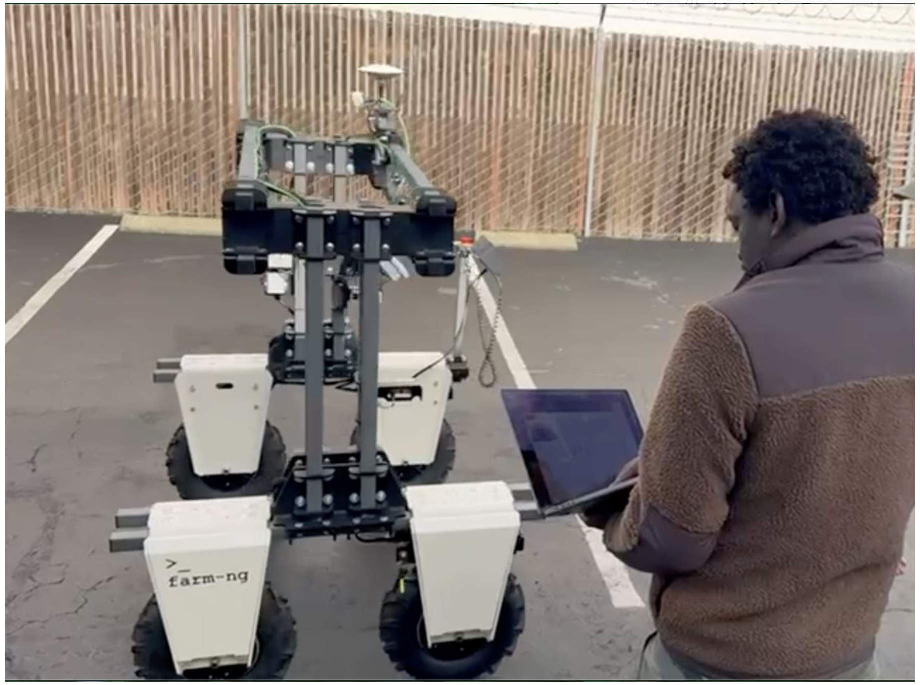
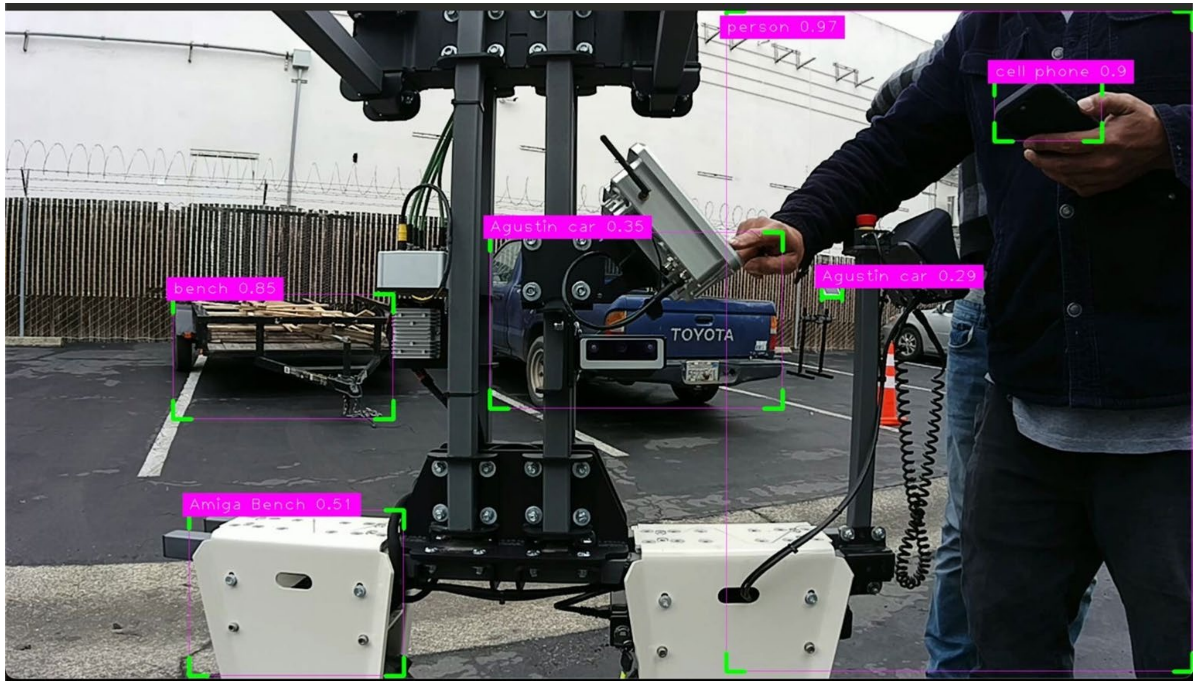
Rapid User Onboarding and User App Development



teleoperation



app development

USDA

Precision Sustainable Agriculture

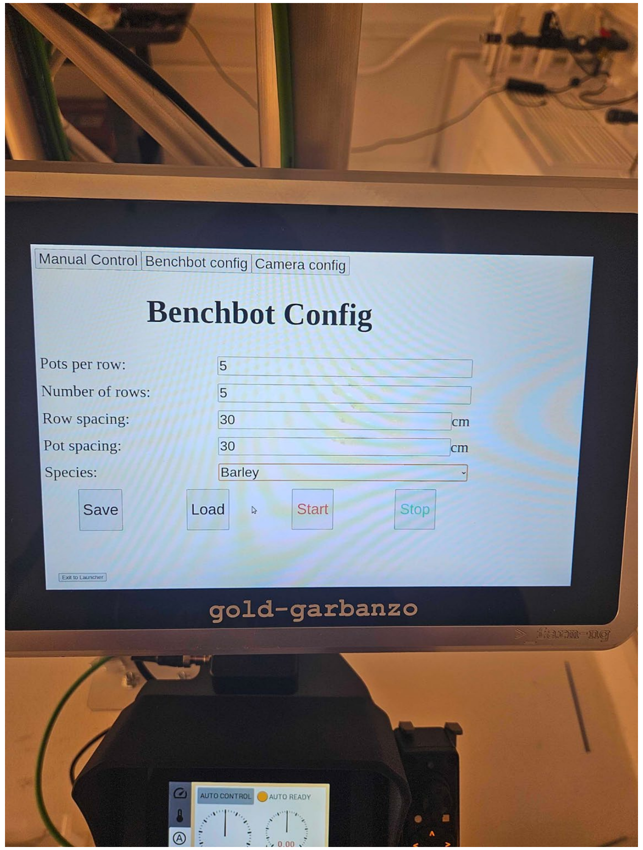
NC STATE UNIVERSITY

Steven Mirsky (USDA) & Chris Reberg-Horton (NCSU)

Mature Ecosystem for Plant Science

Precision Sustainable Agriculture

flexible data collection platform



PSA-developed apps

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Move to Questions for Panelists