Cultivating Caution Series

How Will Technology Shape the Farm of the Future

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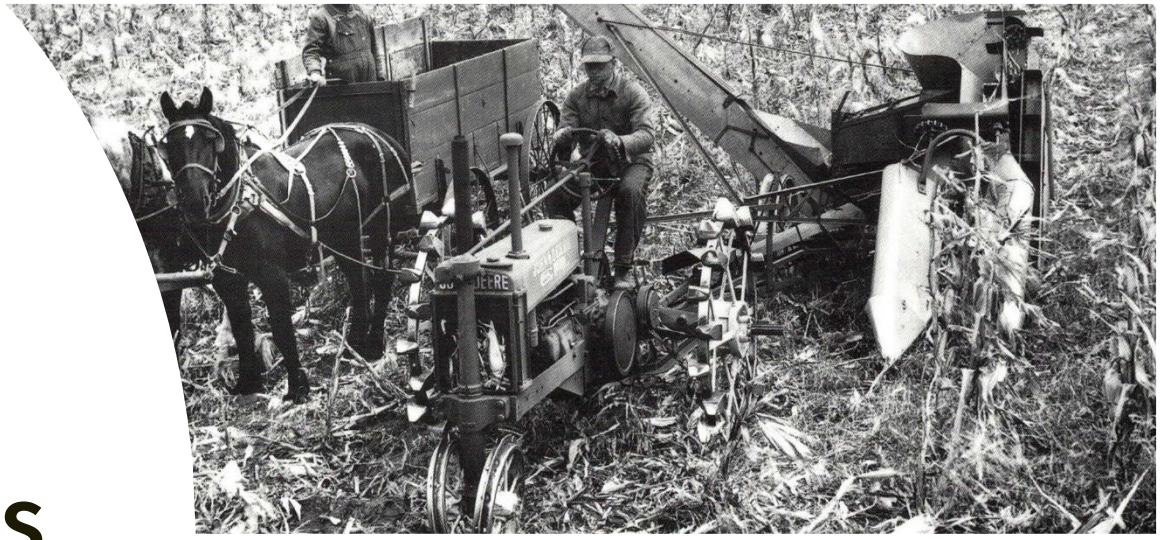
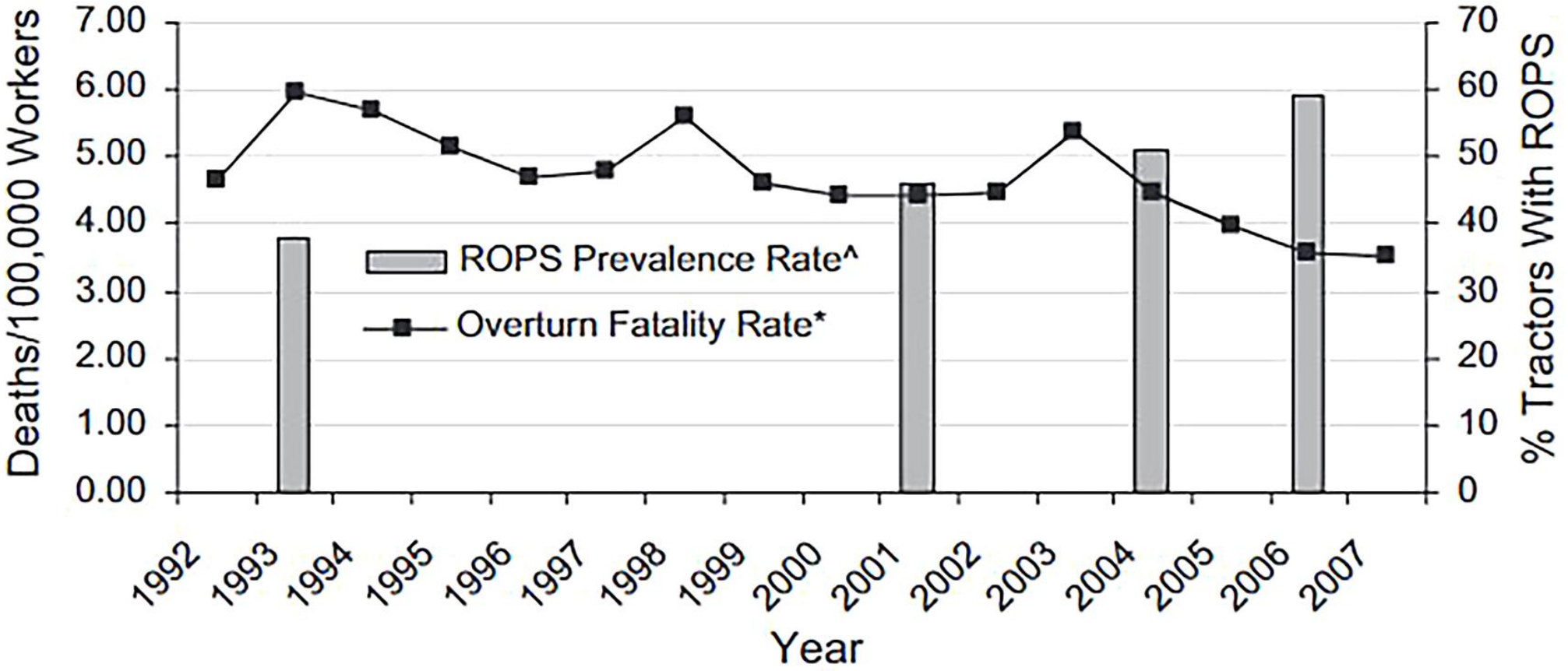
Automation to Autonomy

- Part of a long history of mechanization.
- Focus on Safety in the 1960's
  - Rollover Protective Structures (ROPS).
  - OSHA Standard in 1976



Tractor Rollover Injuries over time



Myers, J. R., & Hendricks, K. J. (2010). Agricultural tractor overturn deaths: Assessment of trends and risk factors. American Journal of Industrial Medicine, 53(6), 662–672.

2022 CROP ROBOTICS LANDSCAPE

The Mixing Bowl | Better Food Ventures

AUTONOMOUS MOVEMENT | **CROP MANAGEMENT** | **HARVEST**

ROW CROP · SPECIALTY FIELD · ORCHARD-VINEYARD

Navigation/ Autonomy
AgriRobot, Cognitive Pilot, Trimble, Sabanto, CHCNAV, FJDynamics, ASI, Steyr, Cerea, GPX Solutions BV, Topcon, Ag Leader, Blue White Robotics, Agtonomy, GOtrack, Braun

Small Tractor/ Platform
Salin 247, Kubota, Donkey, AI.Land, The FarmHand Tractor™, Elatec, Ztractor, farm-ng, Sabi Agri, Korechi, Continental, Future Acres, Monarch, AgreenCulture, exobotic, Burro, Vinergy, Antobot, XAG, Exxact Robotics

Large Tractor
Nexat, John Deere, Combined Powers, AgXeed, Raven, Agrointelli, autoagri, Bear Flag Robotics, EOX, Amos, Tarra, New Holland Agriculture, Sitia, oxin, SlopeHelper, Vitibot

Scouting
EarthSense, Egrobots, Meropy, Solinftec, Small Robot Co, sentera, Censys Technologies, AgEagle, quantum systems, draganfly, Delair, Atmos, wingtra, aerobots, Event 38 Unmanned Systems, microdrones

Robotic solutions placed in other task/product categories on this landscape may have scouting

Preparation & Planting
Fendt, Horsch, Rowbot, TerraClear, Aeroseeder LLC

Drone Application
EAvision, Kray, precision.ai, Guardian Agriculture, Thanos, Forward Robotics, 天途 TTA Aviation, Joyance, Nileworks, M-Drone, Pyka, Lahakx, Drone Volt, Drone4 Agro, Marut Drones, Titan Flying, hylio, dji, Fly Dragon, X-Drone, Hadyi, LeadingEdge Aerial Technologies, BroUAV, Asta, hse, AERO41, Garuda aerospace

Application
Case IH, Carbon Bee, Vresson, Bosch, Augmenta, DAT, Dammann, Bilberry, Amazone, Blue River Technology, Plantium, Claas, Autonomous Pivot, Greeneye Technology, ecorobotix, Verdant Robotics, Tartan Sense, Saga Robotics, TRIC, XMachines, Mechtronix, LJ Tech, Yanmar, Kilter, Guss, edete, Midnight Robotics, Jacto, Inesctec, Free Green Nature

Weeding & Thinning
rootwave, Kongskilde, HayBeeSee, Steketee, Farming Revolution, Nucrop, Vision Robotics Corporation, Farmdroid, Earth Rover, Stout, Carre, Dahlia Robotics, oddbot, Carbon Robotics, F Poulsen Engineering, naio, Farmhand Automation, K.U.L.T., FarmWise, Weedbot, garford, Ekobot, nexus, Feldklasse, Tensorfield, AgriBotix, Aigen, Ferrari, Ullmanna, PixelFarmingRobotics

Specialty Field Harvesting
Muddy Machines, Lapalme Agtech.com, Harvest Croo, Koppert Machines, advanced.farm, Harvest Moon Automation, AVL Motion, Fieldwork Robotics, MiFood Robot, Apex Automation Inc.

Orchard-Vineyard Weeding & Pruning
Vitirover, Wall-Ye, Aigro, Insight Trac, Beagle, Ladybug Robotics, Eleos Robotics, aigritec

Orchard-Vineyard Harvesting
Tevel, OMC, Ripe Robotics, RoboticsPlus, UBot, Fine Field

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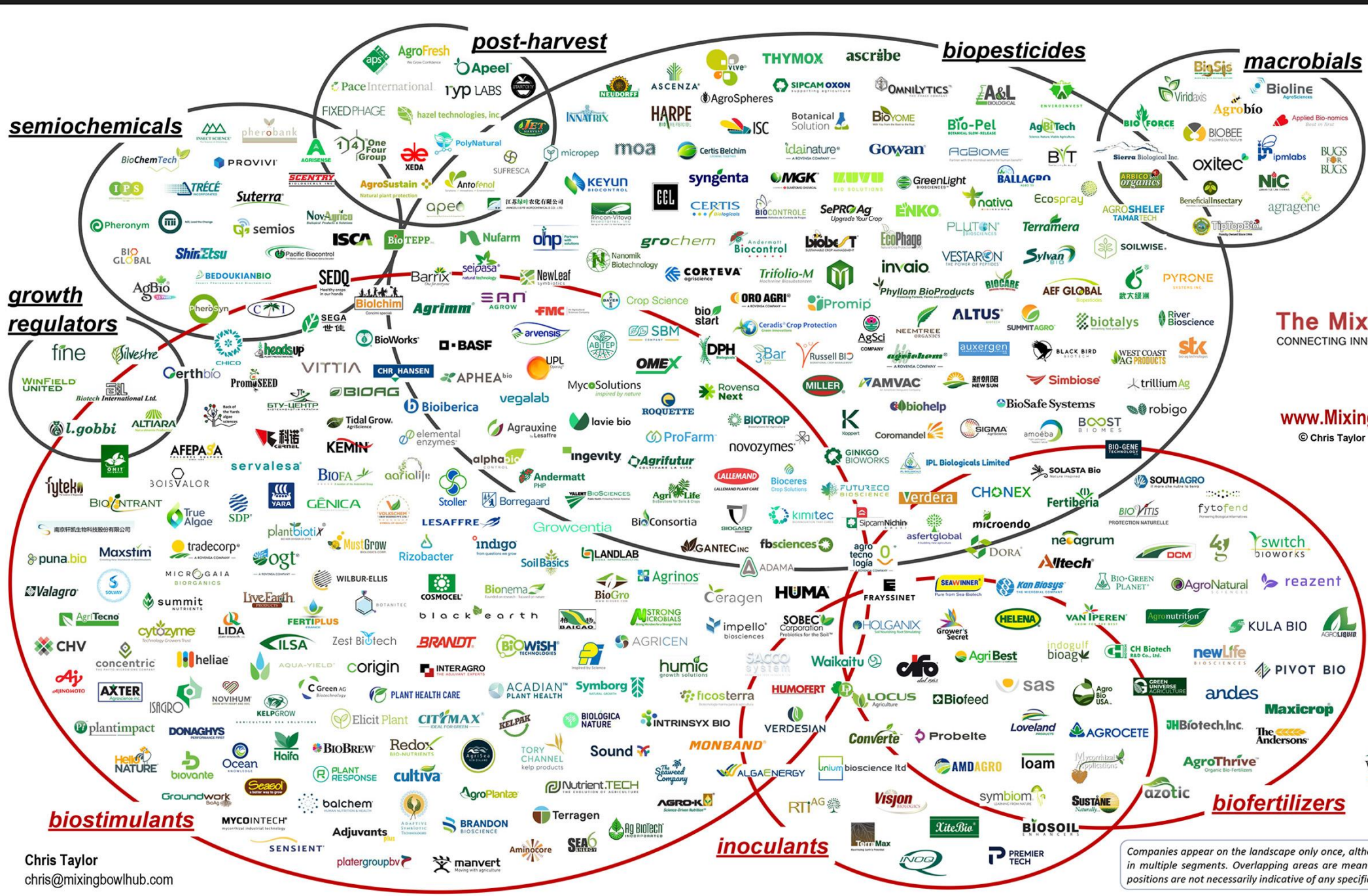
2023 AG BIOLOGICALS LANDSCAPE

BIO-BASED SUBSTANCES

LIVING ORGANISMS

BIOCONTROL

CROP & SOIL HEALTH



Chris Taylor
chris@mixingbowlhub.com

Companies appear on the landscape only once, although some may offer products in multiple segments. Overlapping areas are meant to imply this, however, logo positions are not necessarily indicative of any specific or limited product offerings.

Safety is important

Duct Tape on LiDAR Sensor

Safety Features inside the module?

Case Study

Reported from SAFER Ag Workshop

Company purchased autonomous pressure washer

- Aim to reduce their labor footprint by 1 FTE.
- Found reduction of only 10-20 % FTE.
- Started sending individuals with pressure washer into barn.

Bringing in today …

Naveen Uppalapati

Research Scientist for I-FARM farm of the future project in Illinois

Dennis Bowman

Digital Agriculture Extension Specialist
and Associate Director for I-FARMs

Cultivating caution

How can we incorporate it in emerging technology?

Naveen K Uppalapati
Center for Digital Agriculture

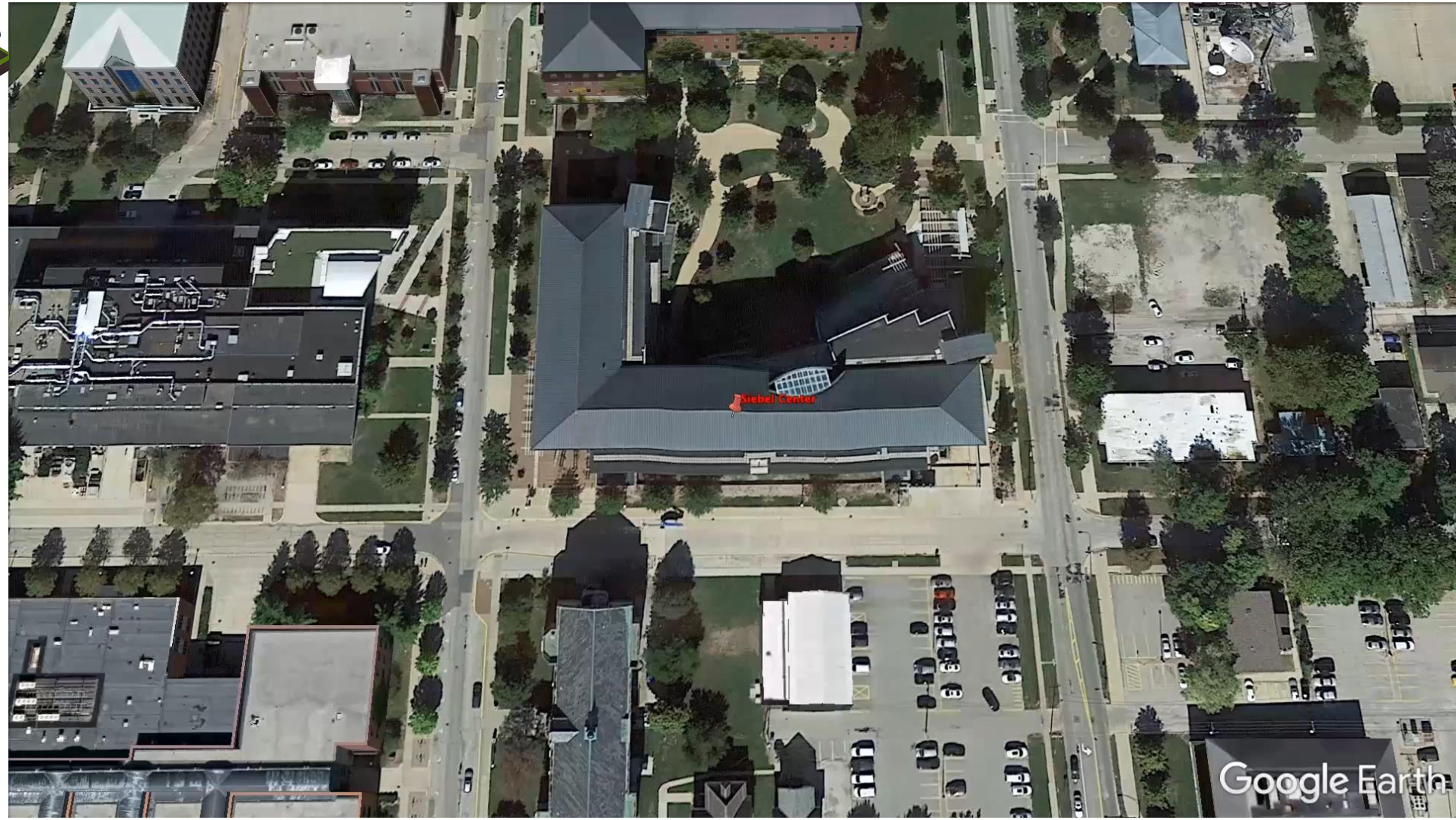
NCSA

ILLINOIS
Center for Digital Agriculture

Farm of the Future

I-FARM

Illinois Farming and Regenerative Management



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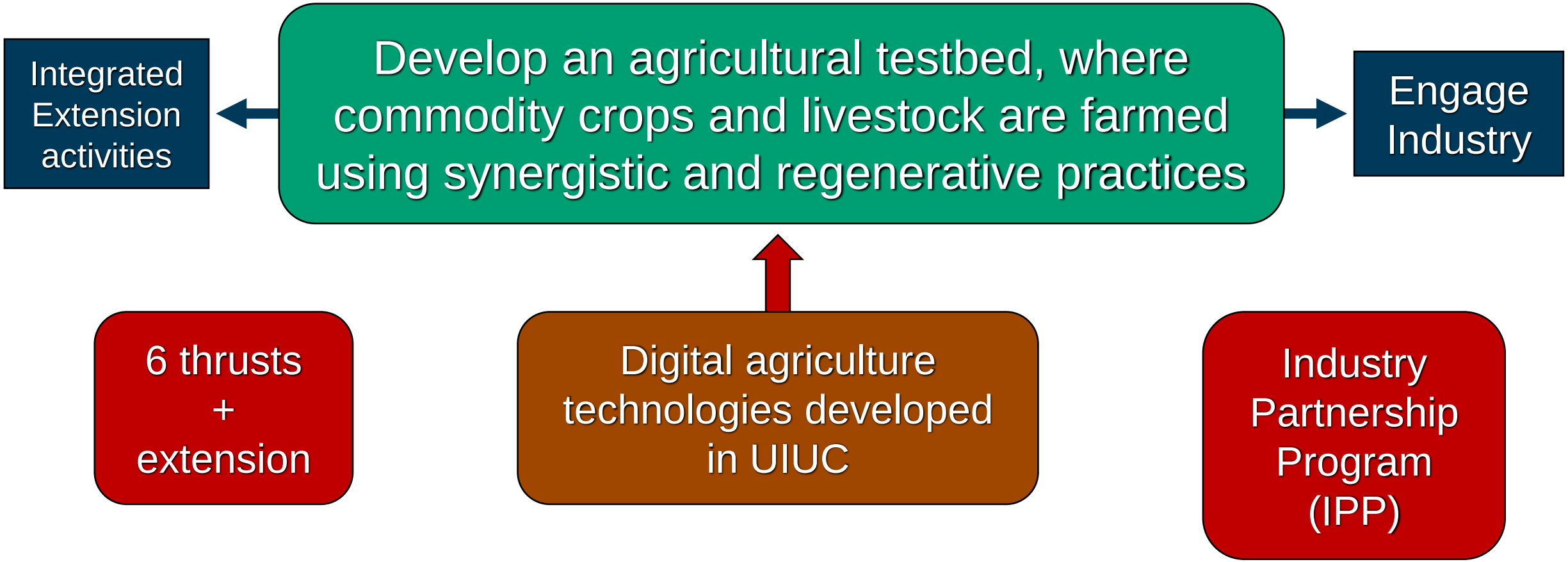
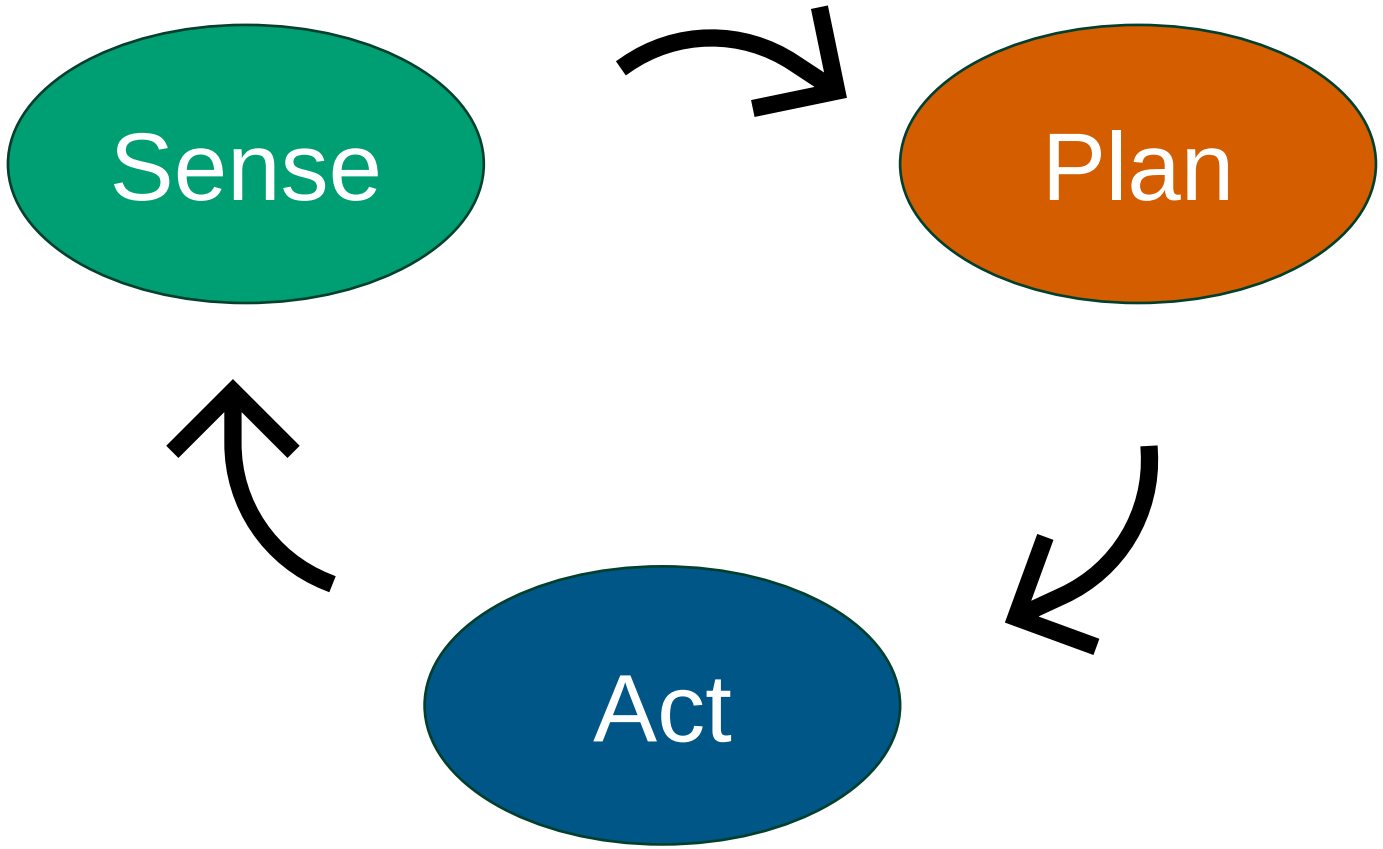
INSTITUTE FOR SUSTAINABILITY, ENERGY, AND ENVIRONMENT

I-FARM mission



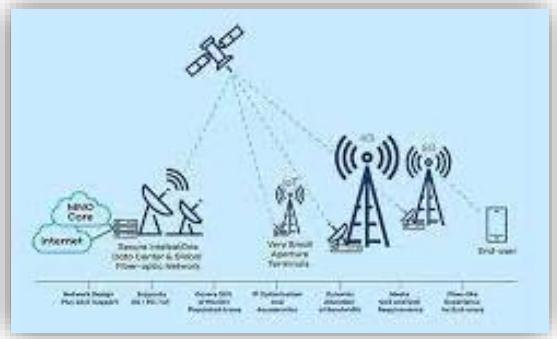
Approaching in a systems perspective



I-FARM Thrusts

Integrating Remote Sensing and IoT in Precision Farming

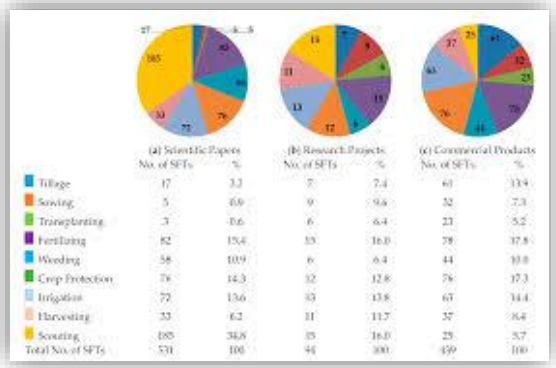
Under Canopy Robotics for Sustainable Farm Management



Rural Internet Connectivity and Edge Computing

Integrating Animals in the Farm of the Future

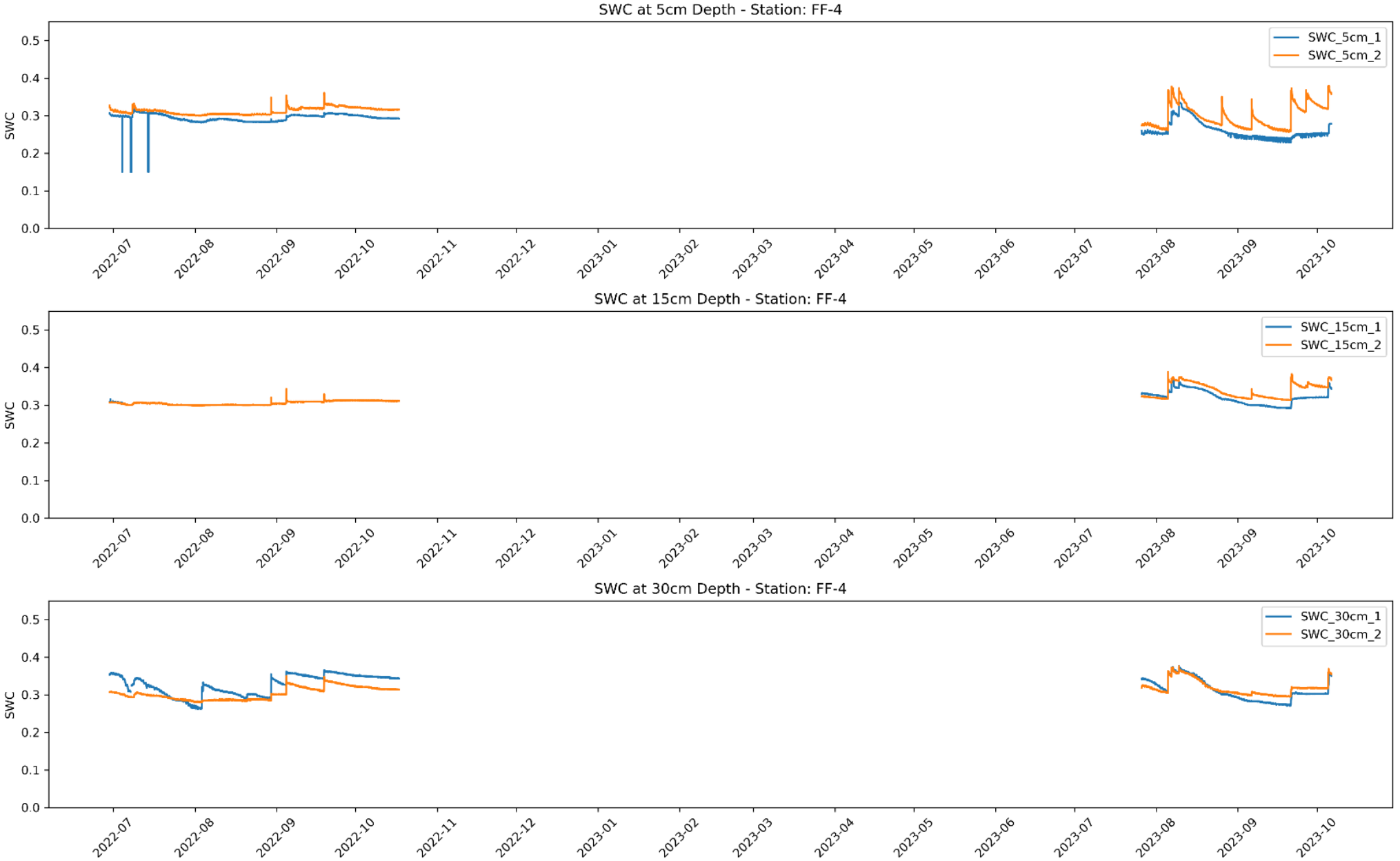
Technology Access to Small-Holder and Minority Farming



Socioeconomics of Technology Adoption

Soil moisture stations in the field

Example of soil moisture time series



LAI monitoring in the field

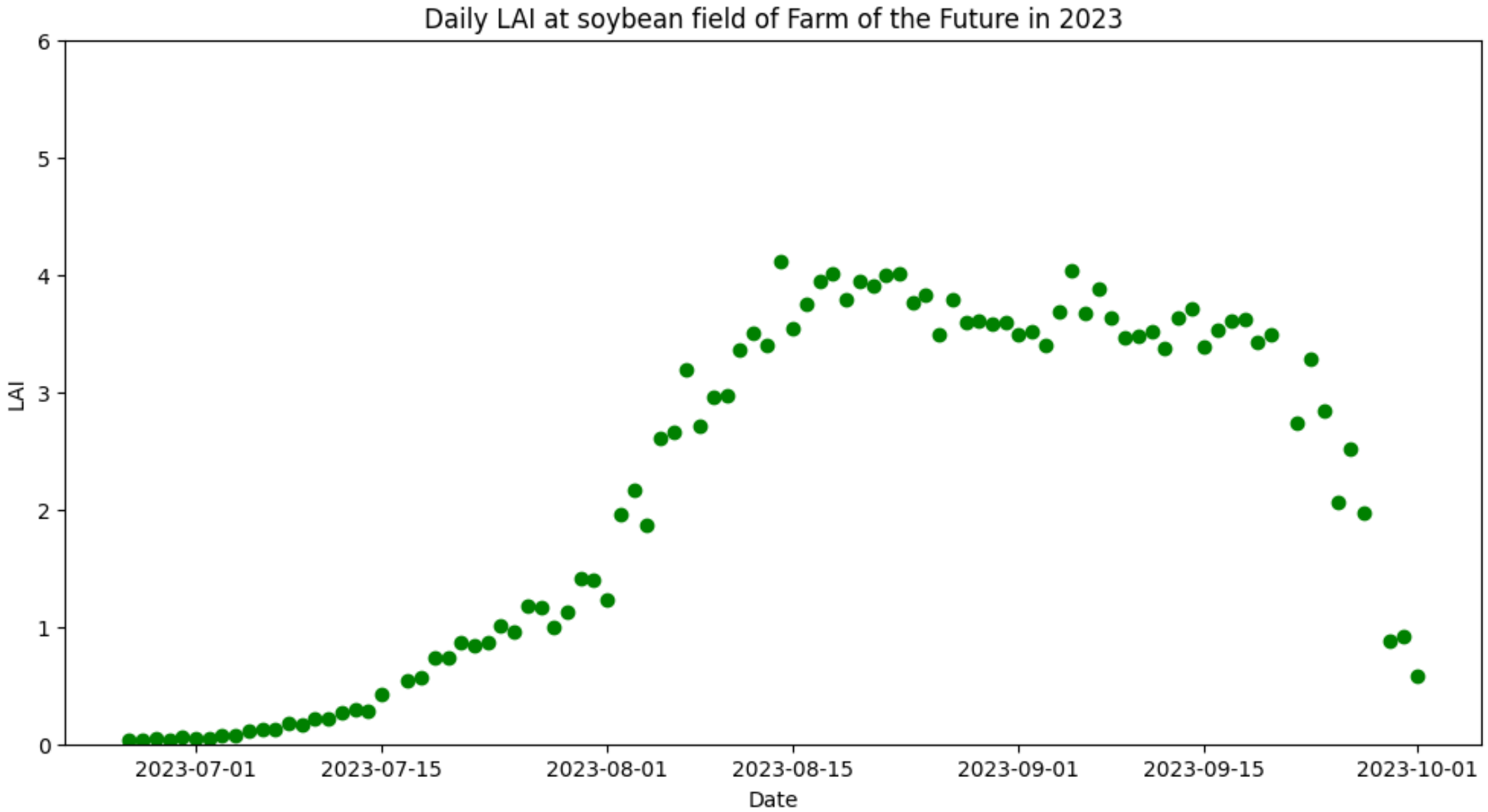
Segmentation → **Calculation** → **Aggregation**

1. Segmentation
2. Calculation of gap fractions based on Beer's law (similar to how LAI 2200 works)
3. Aggregate all cameras' results to get the final LAI

Segmented downward photos

Segmented upward photos

LAI time series



Autonomous CC Robots

July 25th Aug 12th

View video at https://youtu.be/KU3v9XnY4OI

In collaboration with EarthSense Inc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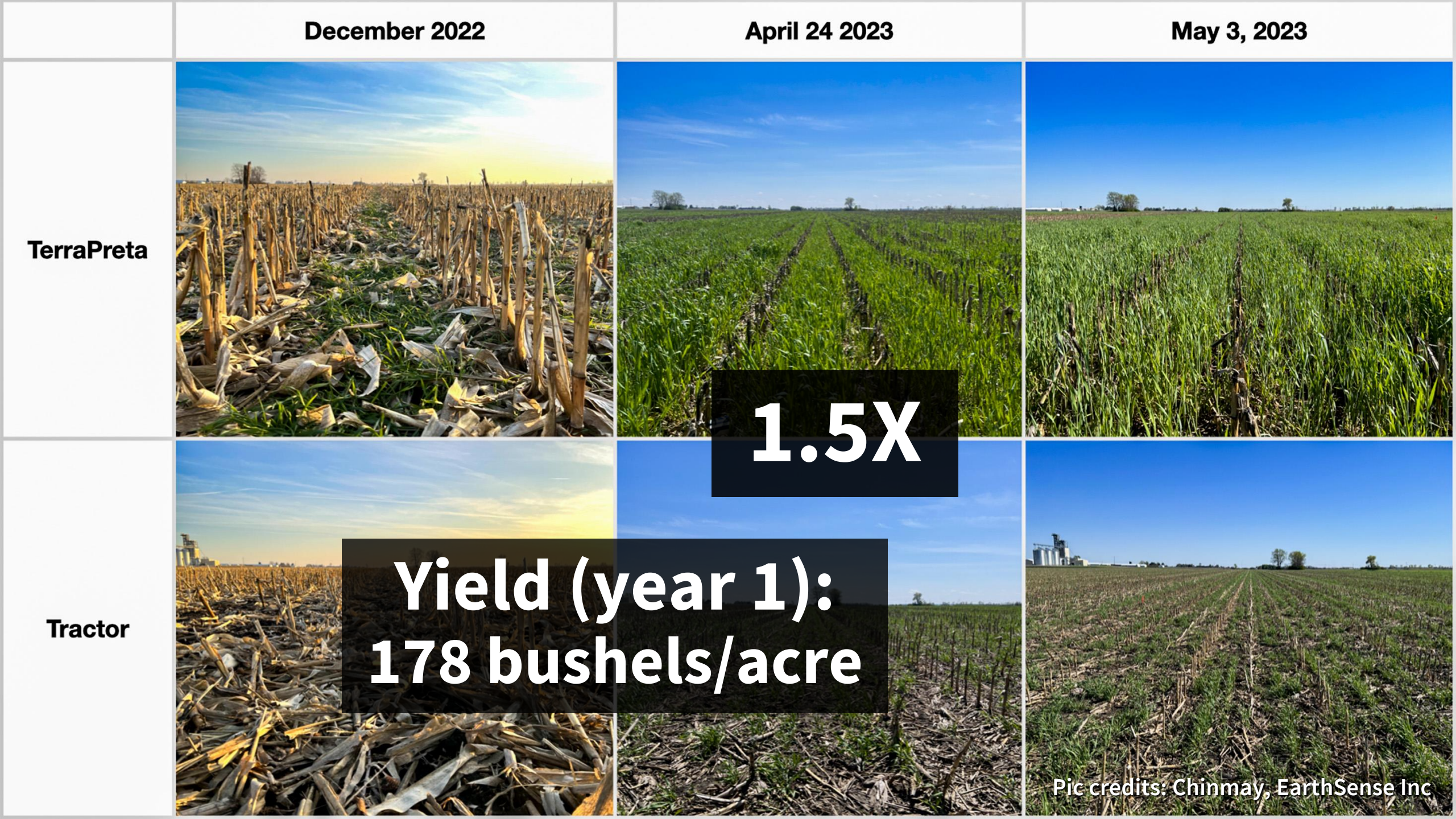

December 2022
April 24 2023
May 3, 2023
TerraPreta
Tractor
1.5X
Yield (year 1):
178 bushels/acre
Pic credits: Chinmay, EarthSense Inc

Cover crop (Ground robots + drones)

View video at https://youtu.be/NNzTvX39zgU

Expensive (due to operator cost)

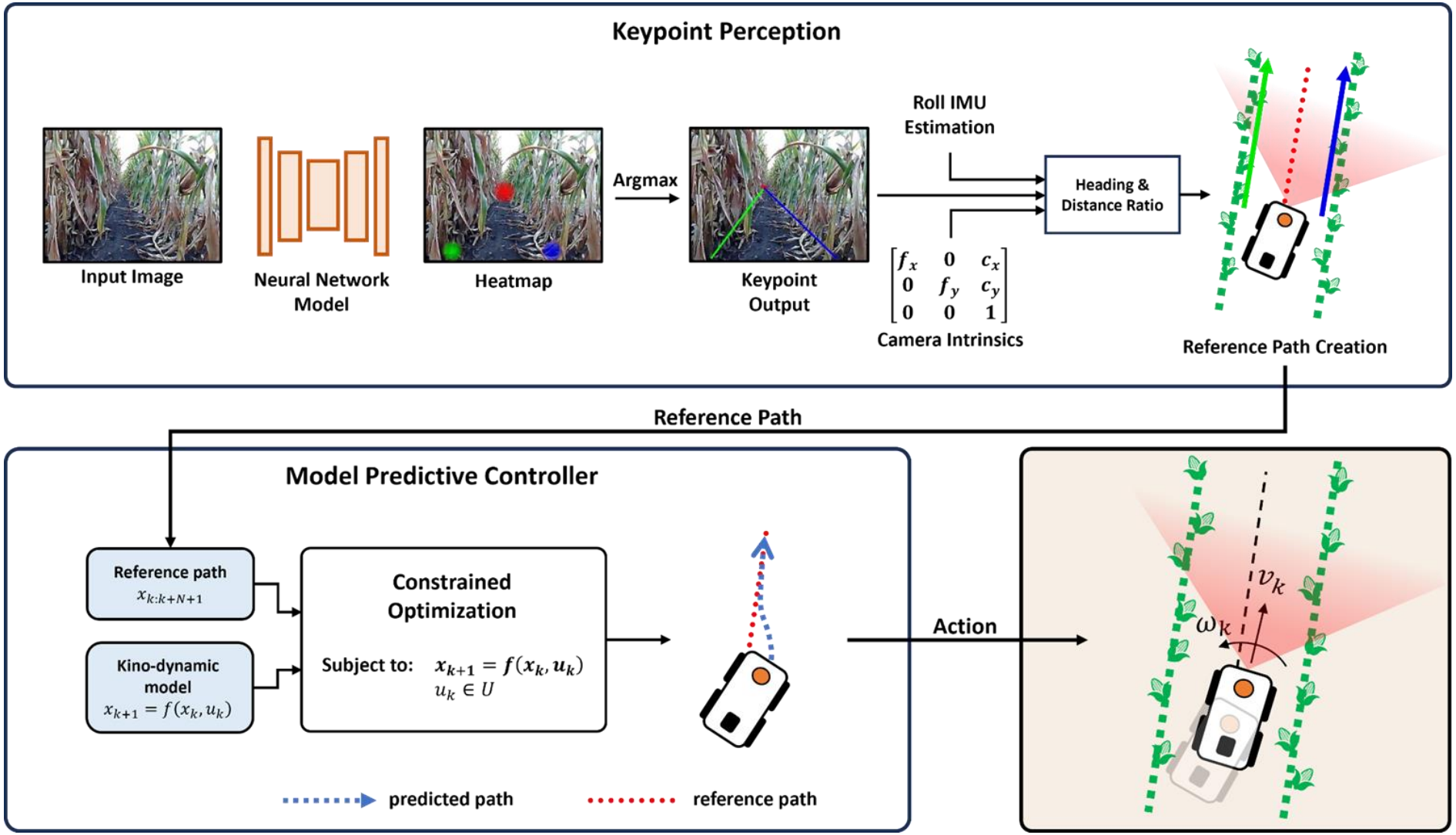
3 robots, 10 acres/hour

Drone Cover Crop Seeding $50/acre

20 acres/hour

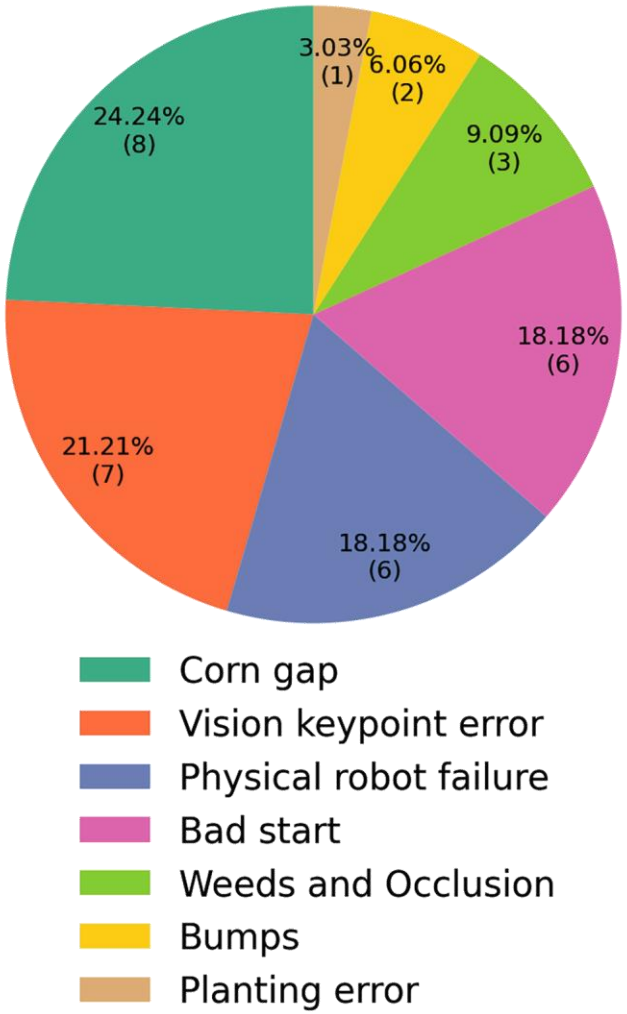
CropFollow++

Vision based undercanopy navigation using keypoints



Cover crop robot tests failure modes

Total number of human interventions needed in ~25km of tests: 33

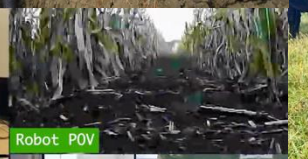


Advancing Agricultural Technology with 5G Connectivity

- Testbed integration
- Teleoperation and data collection
- Centralized AI decision making
- IFARM app as a user-friendly interface for farmers

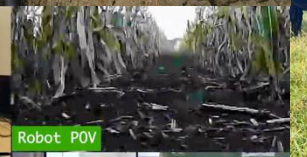
I-FARM: Key highlights

- Unique Crop-Livestock Testbed (115 acres) new experimental designs (9 tiled and fenced plots)
- Advanced Data Acquisition (LAI, soil moisture, weekly drone, daily satellite images)
- Drone Cover Crop Planting (60 acres)
- Enhanced Robot Autonomy (767 m average, best case 3.5 km)
- Full connectivity with CBRS (100 Mbps download)



I-FARM: Key highlights

- Livestock management transition
- Deploying tech in small - scale farms and helping farmers
- Extensive extension activities (1,000+ attendees)
- Integration of robots with livestock
- Season-round data collection (drone, LAI, soil moisture)



Technology can be used to improve the safety

- Early in our journey to achieve this goal, but moving step-by-step
- Sensors can provide more info and with remote sensing give us insights
- Under canopy autonomous robots will reduce the passes of large equipment
- Connectivity will enable to scale and make the robots and sensors more efficient
- Data might show us we can approach this problem in a different way??
- Use robots, drones for herding animals.

Naveen, uppalap2@Illinois.edu
I-FARM Website: https://i-farm.illinois.edu

I-FARM Team

















I-FARM Team

- Arun Narenthiran
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- Italo Lima
- Emerson Sie
- James Shin
- Jiaming Xu
- Menglin Liu
- Aganze Mihigo
- Rutva Pandya
- Kavin Jindel
- Aditya Sengupta
- Anushka Pachaury
- Postdocs
- Research technicians
- Grads
- Undergrads
- Farm team
- Timothy Lecher

Cultivating Caution

May 21, 2024

New Technology in Agriculture

Illinois Extension

Technology adoption

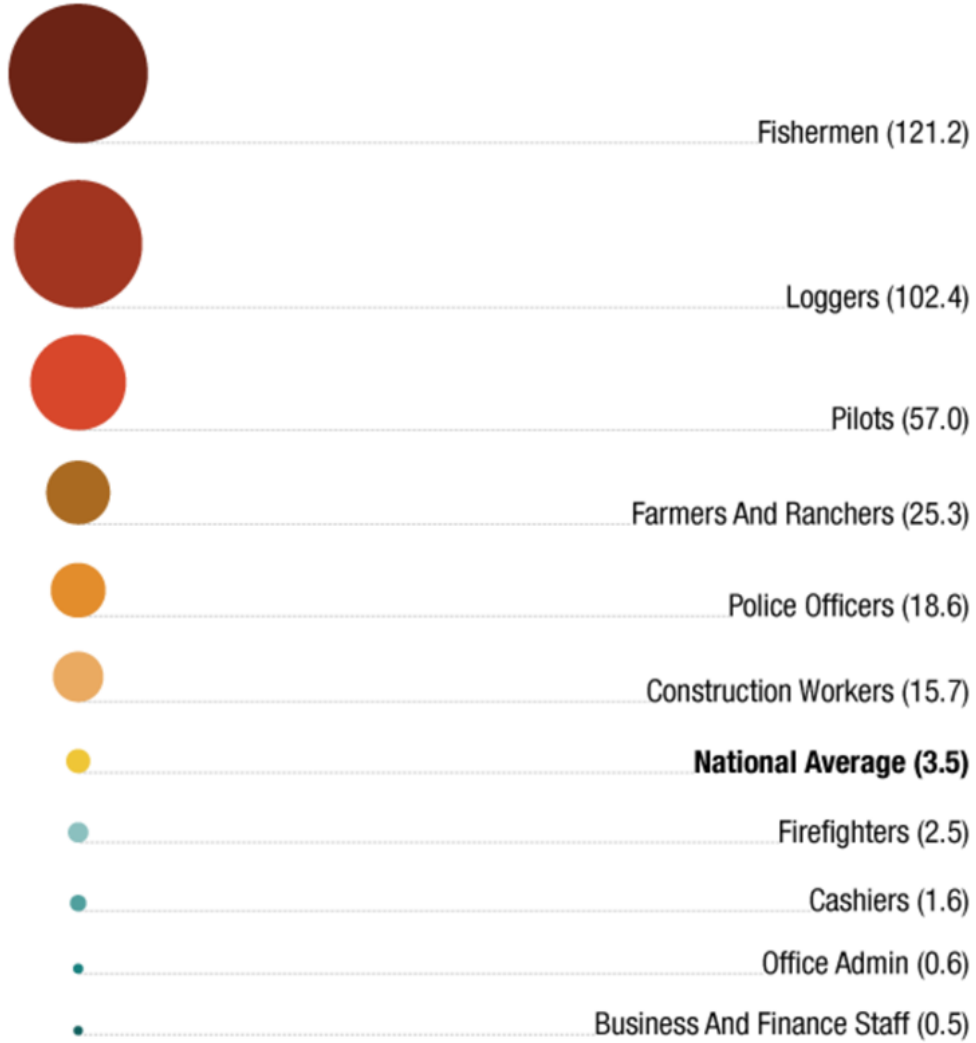
- First agricultural revolution: Move from hunter-gatherers to farmers, domestication of crops and livestock
- Second agricultural revolution: The adoption of mechanization and access to markets
- Third agricultural revolution: Hybridization, commercial fertilizers, pesticides
- Fourth agricultural revolution? Information, AI, robots

ChatGPT 4.o: Create a limerick about agricultural autonomous technology and safety

4 D's of Automation: Drones/Robots

- Dull
- Dirty
- Dangerous
- Dear

Work-Related Deaths, 2011 (Per 100,000 Workers*)



* Full-time equivalent workers.

Source: Bureau Of Labor Statistics

Credit: Jess Jiang and Lam Thuy Vo /NPR

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NTSB: 2023 Ag Aviation 56 accidents (7 IA & IL) 12 fatal

Potential Advantages: Safety

- No Pilot
- No 254 gal aviation fuel*
- No 800 gal pesticide*
- Drone flights stay within field boundaries
- Drone safely operates at lower altitude
- vs. Backpack sprayers?

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*Air Tractor 802A $2.5m

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Front and Back Phased Array Radars
for terrain and obstacle detection

Image courtesy Talos Drones and DJI Technology Co.

Increased productivity,

Worker benefit?

Burro

Photographer, Salah Issa, 2022 FIFRA Conference


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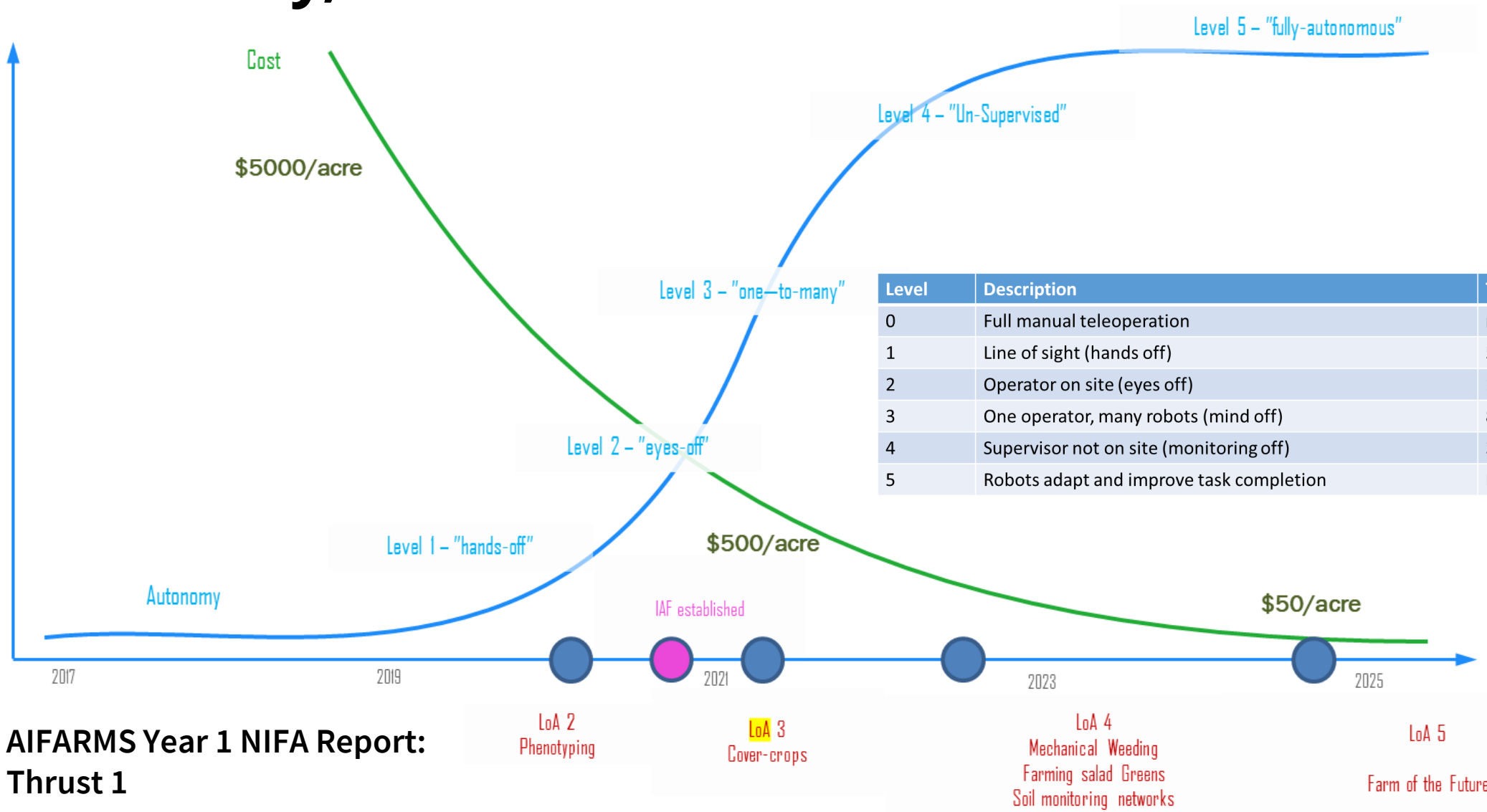
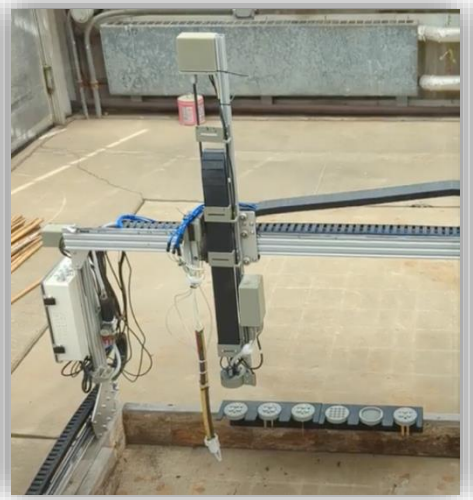
Ag Robot Development (AIFARMS) Autonomy, Time and Cost

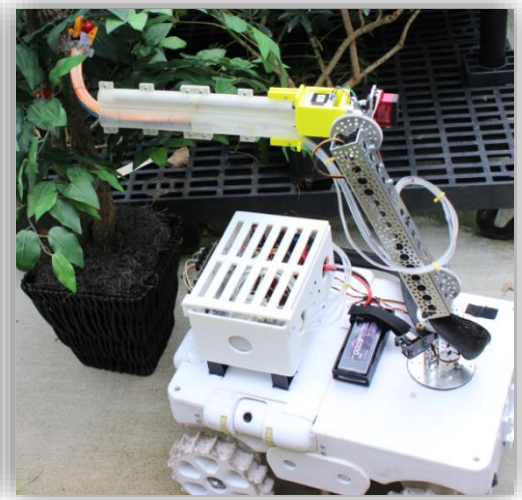


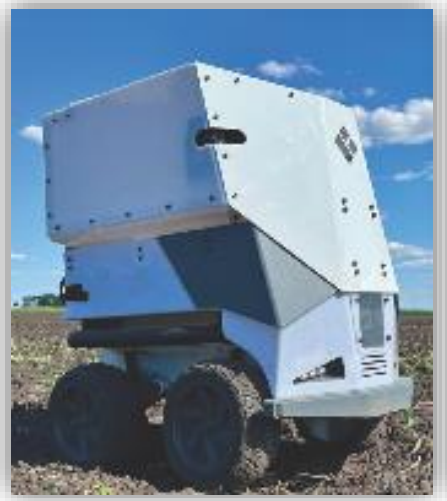
Level	Description	Time between Interventions
0	Full manual teleoperation	n/a
1	Line of sight (hands off)	5 min.
2	Operator on site (eyes off)	1 hour
3	One operator, many robots (mind off)	8 hours
4	Supervisor not on site (monitoring off)	3 days
5	Robots adapt and improve task completion	Extended operation

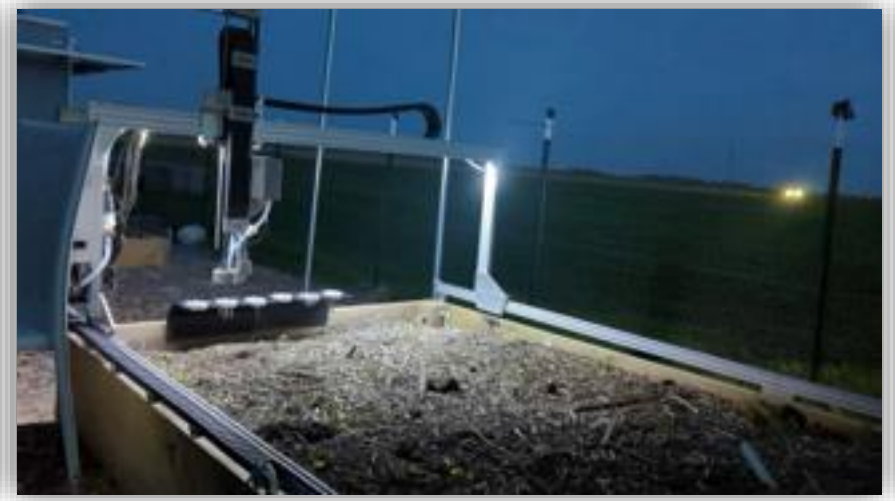
AIFARMS Year 1 NIFA Report: Thrust 1

Our Team of Agbots









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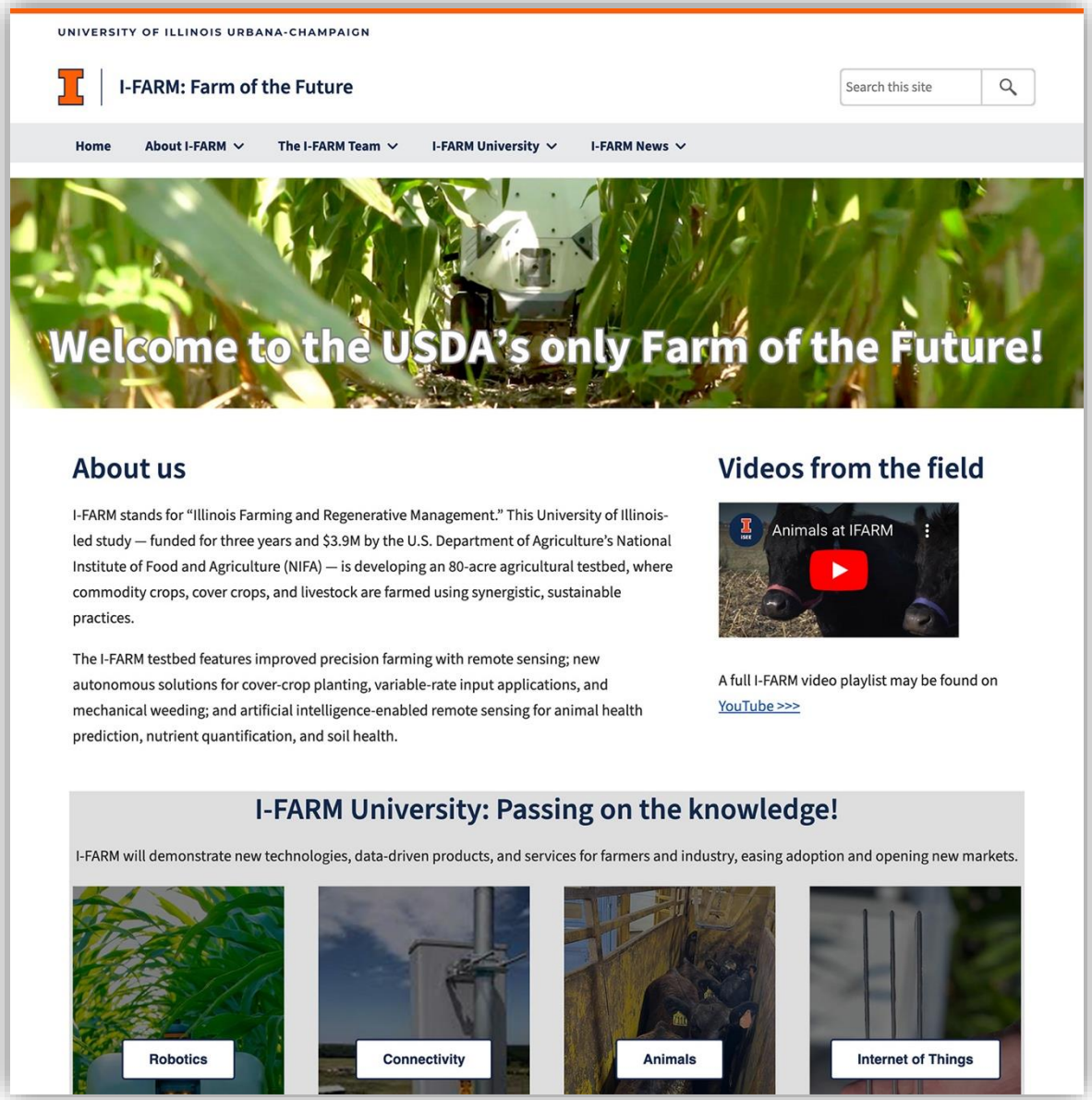

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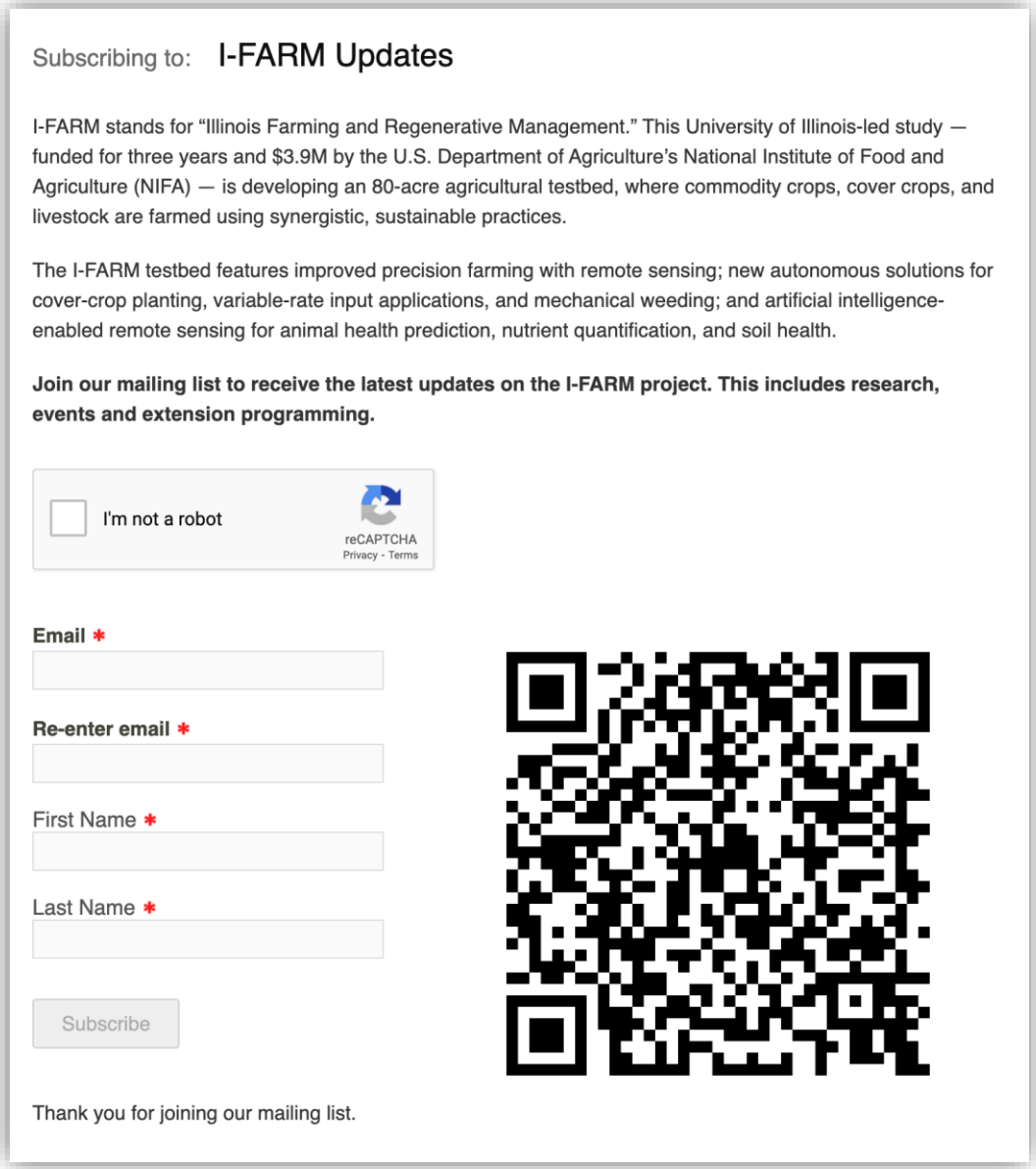

Our next upcoming event....

Farming for the Future:

Digital and Regenerative Ag Integration

August 15th, 2024
@ I-FARM & Regenerative Ag farms

Subscribe for more information:
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Thank You for joining us!

Heat Illness – 6/18

Explanation of how heat exposure affects agricultural workers and effective strategies for prevention.

Illinois Injury Report– 7/16

Overview of agriculture-related injury and illness tracking programs active in Illinois.

Farm Safety for Youth – 8/20

Why young people are uniquely vulnerable to farm hazards. We will review child labor laws and resources for legally employing youth in agriculture.

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