Transforming Agriculture using AI

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Biocomplexity Institute@ University of Virginia

Our diverse research team unites different perspectives and skills, all driven by a common goal: using computational tools to solve challenging problems of societal importance

Key areas of expertise:

- Artificial Intelligence
- Digital Twins
- HPC
- Network Science

Together, we work to foster global collaborative networks to advance our unique research agenda, support decision makers, and develop innovative experiential learning programs for students

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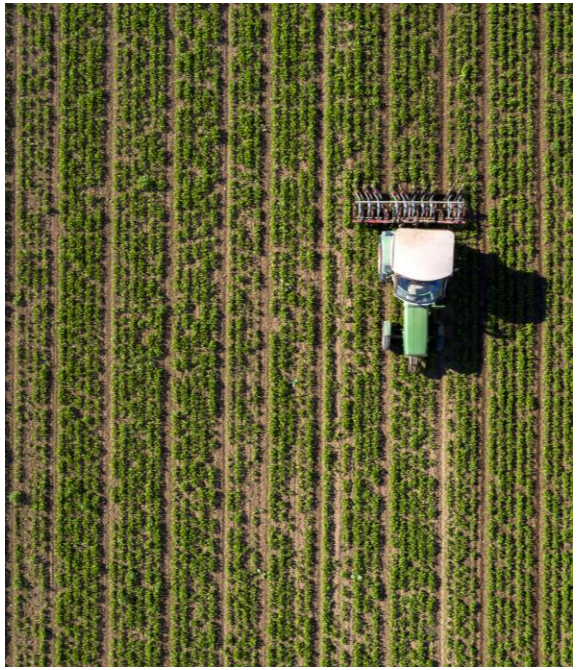
Agriculture in the 21st Century

New challenges:

- Environmental: Extreme weather, increased population, lack of arable land, water shortage, pests
- Social: Labor force, demand for high valued foods
- Technological: Advent of new sensing, computing and AI technologies



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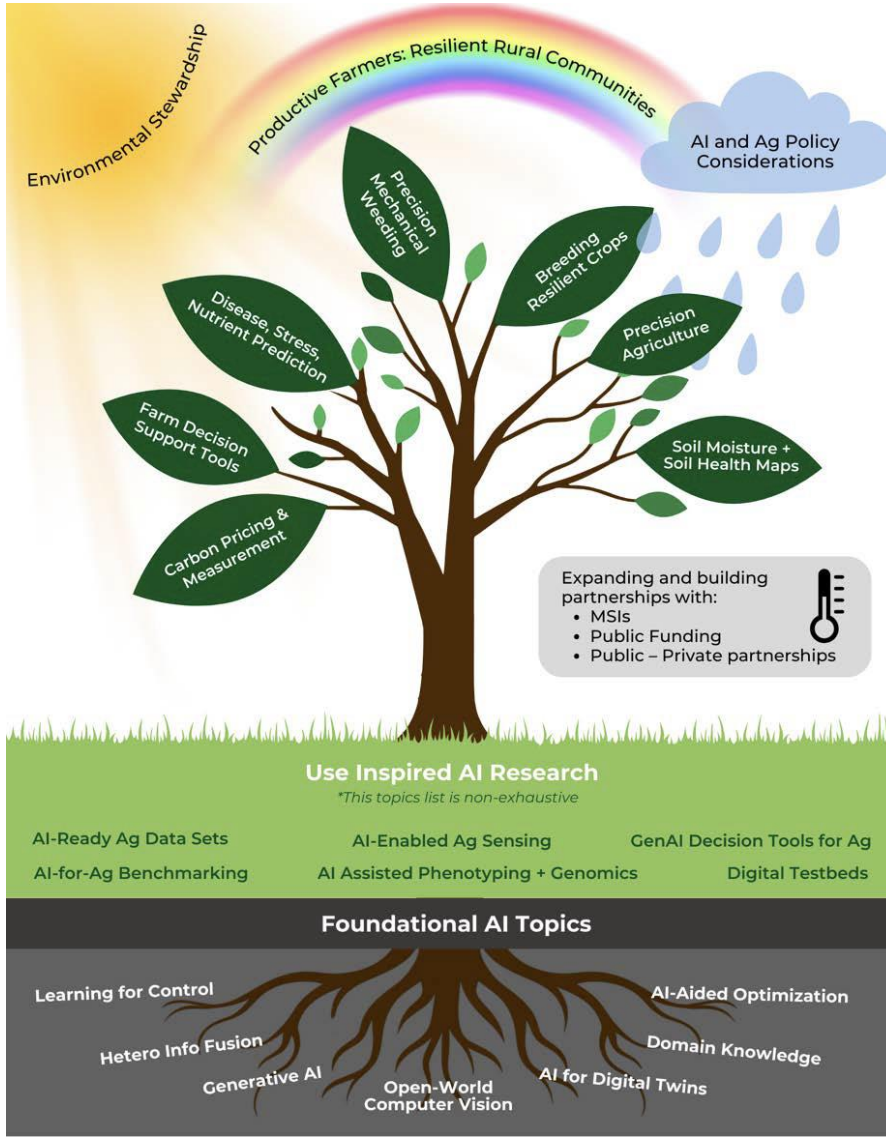
AI has the Potential to Transform Agriculture

- Current and Future advances in AI can ensure that future agriculture is environmentally friendly, sustainable, affordable, and accessible to diverse farming communities

Will need a strategic partnership between AI technologists, policy makers, farmers & farm workers and agro-industries



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How AI can Transform Agriculture

Farm productivity + rural prosperity

1. AI can enhance efficiency of food / fuel / feed / fiber production
2. AI research reduces the costs for farmers
3. AI / tech make farming and Ag careers more attractive to the next generation

National security + leadership

1. Dramatic AI advances demand significant investments to maintain US leadership
2. US investments in AI research lag key competitors
3. AI researchers are critical for Ag progress

Environmental sustainability

1. AI enables more sustainable farming practices
2. AI can reduce environmental harms

Workforce development

1. Critical need for AI expertise in Ag industry
2. AI expertise needed among Ag consultants, educators

AgAID: An AI Institute for Transforming Workforce and decision Support in Agriculture

Follow us on agaid.org, agaidinstitute @linkedin] *www.agaid.org*

Funded by:

USDA National Institute of Food and Agriculture
UNITED STATES DEPARTMENT OF AGRICULUTRE

in partnership with: NSF

Washington State University

Oregon State University

Wenatchee Valley College

Heritage University

University of California Merced

University of Virginia

innov8.ag
EMPOWERING GROWERS WITH DATA

Kansas State University

The AgAID Institute is one of the 5 AI for Agriculture Institutes and one of the 27 AI Institutes funded as part of the **National AI Research Institute** program and is funded by USDA NIFA.

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Unique Approach and Three Thrust Areas

Our **Farm Intelligence Thrust** is developing tools to support decision-making at the farm scale, helping farmers manage the impacts of extreme weather and other uncertainties.

Heat Stress
Improved heat-stress prediction models to manage crop loss and improve the quality of farm produce

Frost Mitigation
improving machine learning models for cold-hardiness prediction for specialty crops | supporting grower decision making using AgWeatherNet

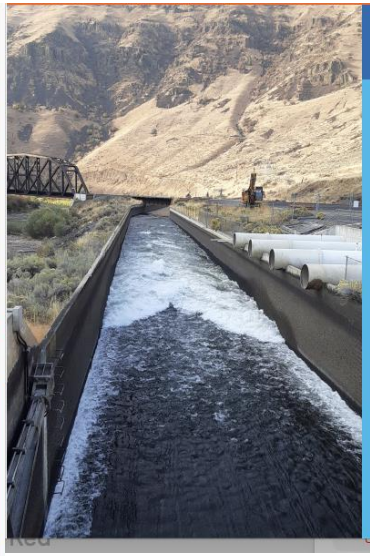
Deficit Irrigation
innovating neural networks to improve site-specific weather and soil-water content prediction

Our **Labor Intelligence Thrust** is developing innovative and inclusive human-AI workflows and improving the efficiency of farm robots and the productivity of farm workers.

Human-Robot Dormant Fruit Tree Pruning
Training machine learning models for pruning | simulating orchard environments | improving robot sensing and control

Human-Robot Fruit Tree Flower and Blossom Thinning
Improving flower-thinning decision making and workflows | developing deep learning models for for flower detection

Nut Harvesting
Developing the next generation of nut harvesting machines | Cutting-edge AI control systems to optimize tree-nut shaking



Our **Water Intelligence Thrust** is designing AI solutions to assist better stewardship of water resources, and addressing water scarcity challenges.

Fallow Prediction
developing empirical and simulation-based models to predict fallowing of drought-affected irrigated cropland

Streamflow Prediction
improving overall streamflow prediction accuracy and uncertainty quantification using deep temporal AI models

Snow Water Equivalent Prediction
developing a machine learning model to reliably predict snowpack and snowmelt

Irrigation Infrastructure Mapping
Mapping the network of canals and waterways from remote sensing images through deep-learning

The *Adopt-Adapt-Amplify* Approach:

- **Adopt**ion as a first principle in AI design
- **Adapt**ability to changing environments and multiple scales
- **Amplify**ing human skills and machine efficiency through a close human-AI partnership

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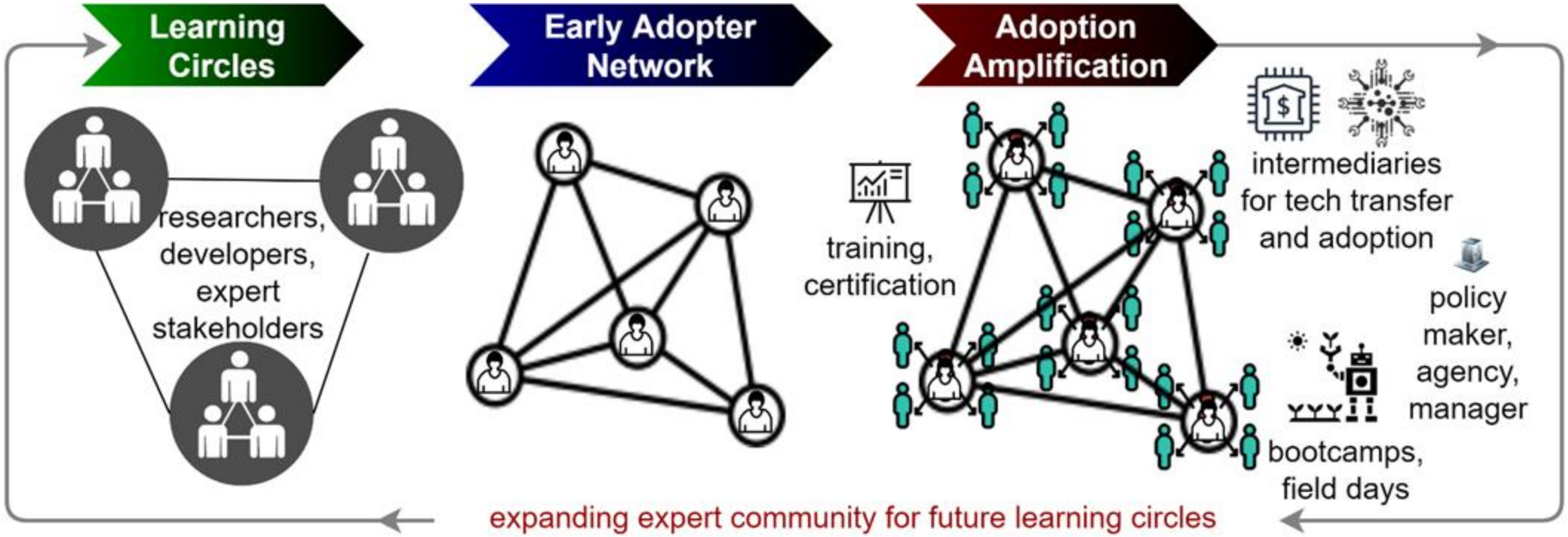
AgAID Learning Circles and Adoption Flywheel



Example learning circles:

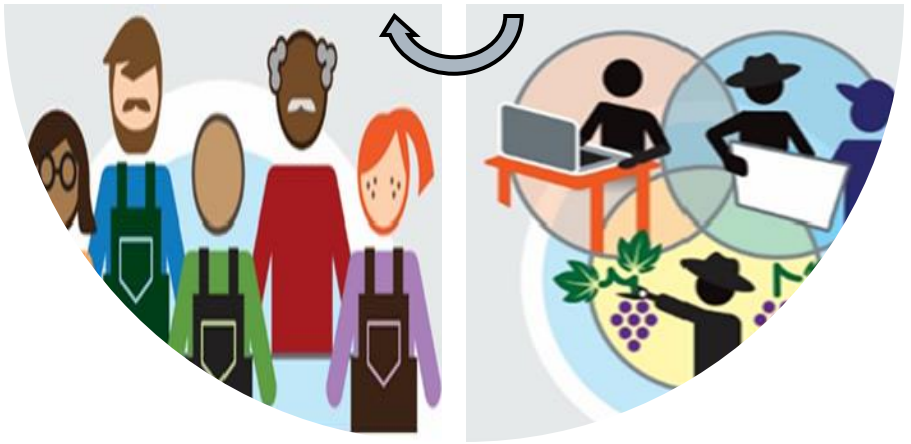
1. Columbia Basin Tree Fruit Club
2. WA Statewide Water Policy Group
3. Farm workers

AgAID Strategic Implementation

AG ACCELERATION
Increase productivity & quality, manage risks better, and improve profitability

AI ACCELERATION
Increase innovations in AI, its design approach (fair, responsible, explainable) for social good domains

COMMUNITY ACCELERATION
Revitalize rural communities with new pathways and job opportunities, and build trust in AI



WORKFORCE ACCELERATION
Prepare next generation workforce in in AgTech & FarmTech, while helping current workforce innovate and co-create technology

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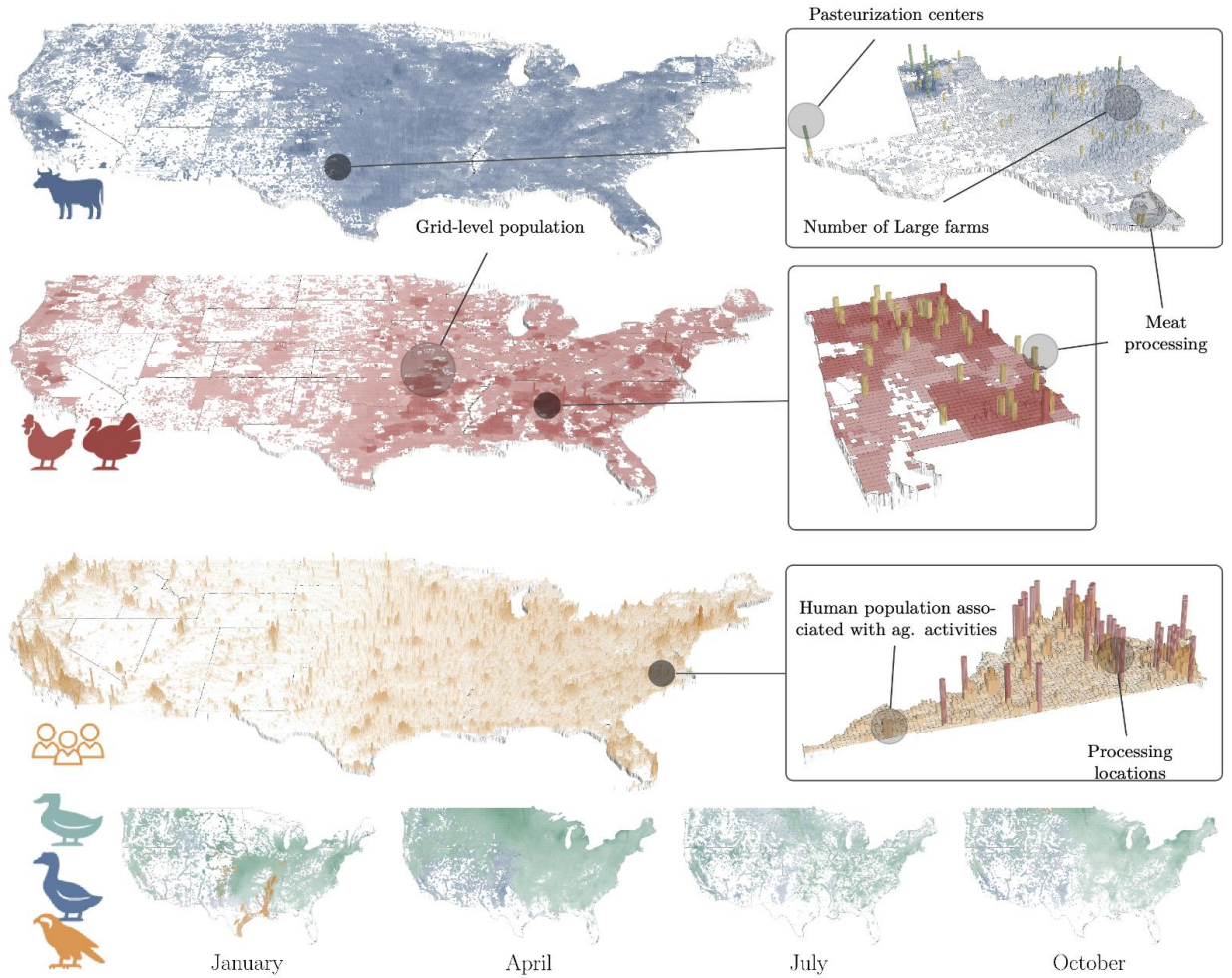
Livestock Digital Similar

A US-scale multi-layered high-resolution digital representation of:

- **Livestock**: Multiple farm-level livestock populations modelled from Census of Agriculture and Gridded Livestock of the World datasets
- **Processing centers**: Milk, meat, eggs and poultry
- **Human population**: By size and occupation type based on our US v2.4.0 digital similar
- **Wild birds**: Multiple species of migratory birds from eBirds Avian Abundance data



- More about this in preprint: https://arxiv.org/abs/2411.01386
- Data visualization and downloads at https://ditto.bii.virginia.edu

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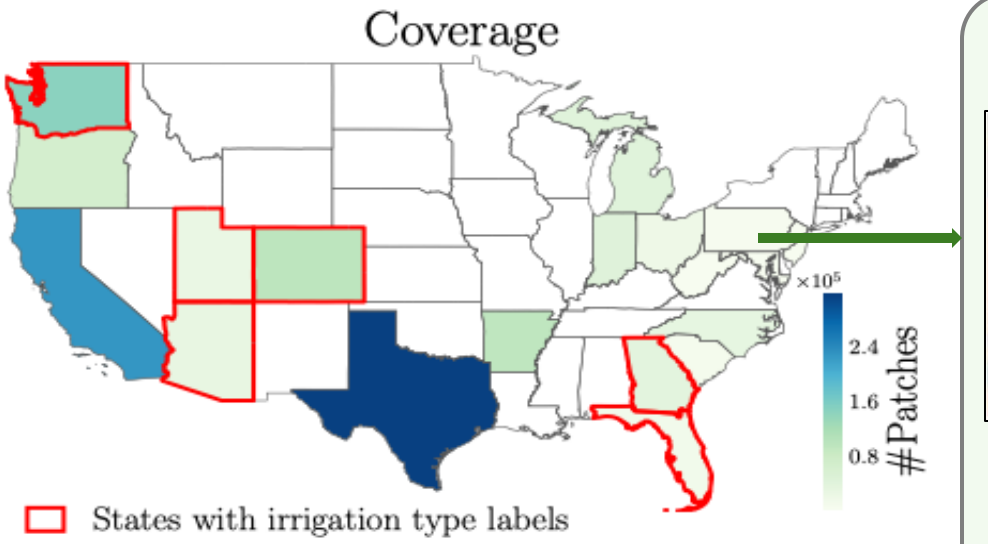
IRRISIGHT: Large-Multimodal fusion for irrigation mapping and beyond



#Patches	
Labeled	293,890
Unlabeled	1,190,411
Total	**1,484,301**

RGB Composite (Sentinel)

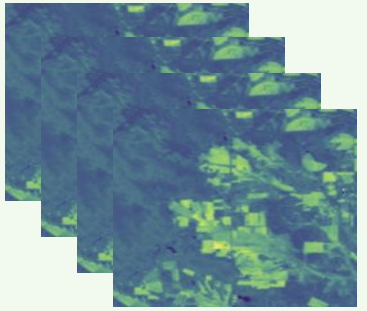
Ag Land Information

Land Index (pixel level)

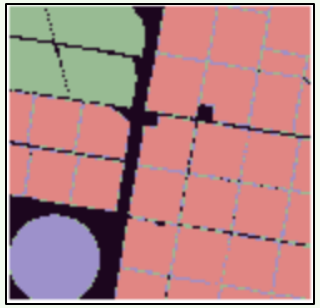
Crop Type Information

Crop Index (pixel level)

13 Vegetation Index: NDVI, NDTI, etc



Multispectral Data (pixel level)



Irrigation Mask

21 Irrigation Relevant Environmental Features

Patch Aligned Generated Prompt

Image from Pinal county, Arizona. ET: 106.99 mm, precipitation: 0.00 in, ground water: 238.82 ft, and surface water: 2.90 ft. This soil unit components: cuerda. The geomorphic setting: alluvial fans. Soil texture.....

Environmental Meta Features (patch level)

A Large-Scale Multimodal Dataset and Scalable Pipeline to Address Irrigation and Water Management in Agriculture, KDD, IJCAI

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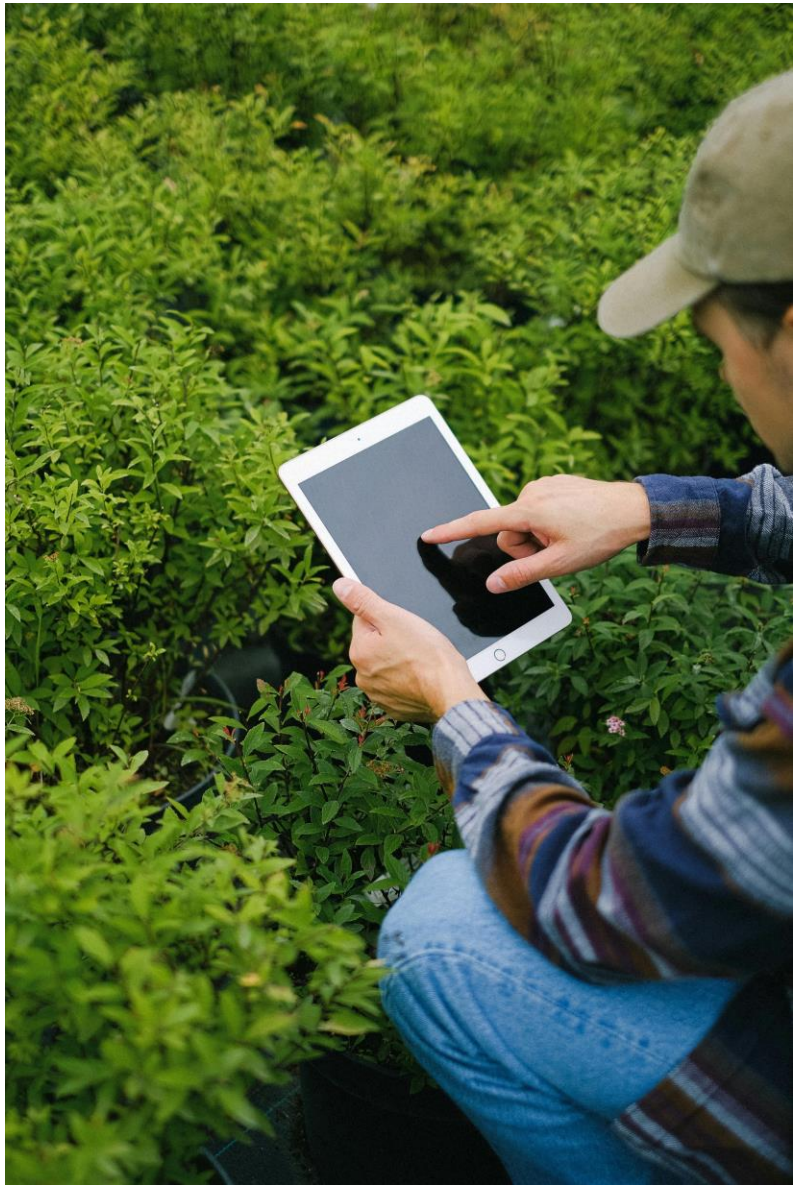
Conclusions

- AI has the potential to transform the practice of agriculture and bring prosperity to the farming community
- For this to be successful, a strategic partnership between AI technologists, farming community, industry and policy makers is needed to ensure that AI technologies can assist farmers and farm workers achieve their goals
- *Special thanks to Vikram Adve (PI, AIFARMS, UIUC) , Ananth Kalyanaraman (PI, AgAID, WSU), and the BI team (UVA)*



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AI on the Farm

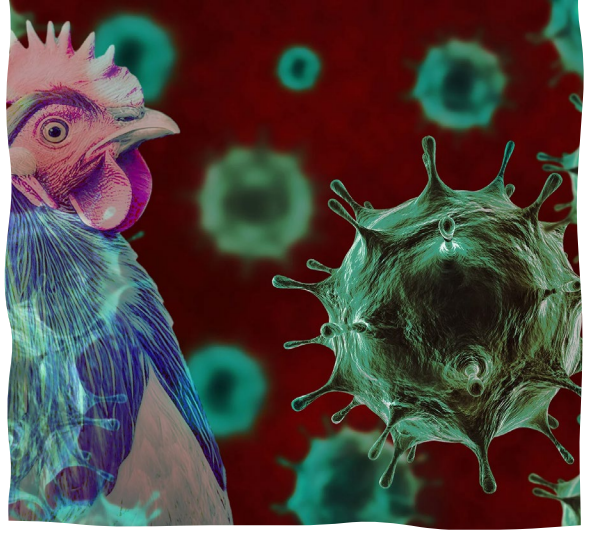
Forrest Anders

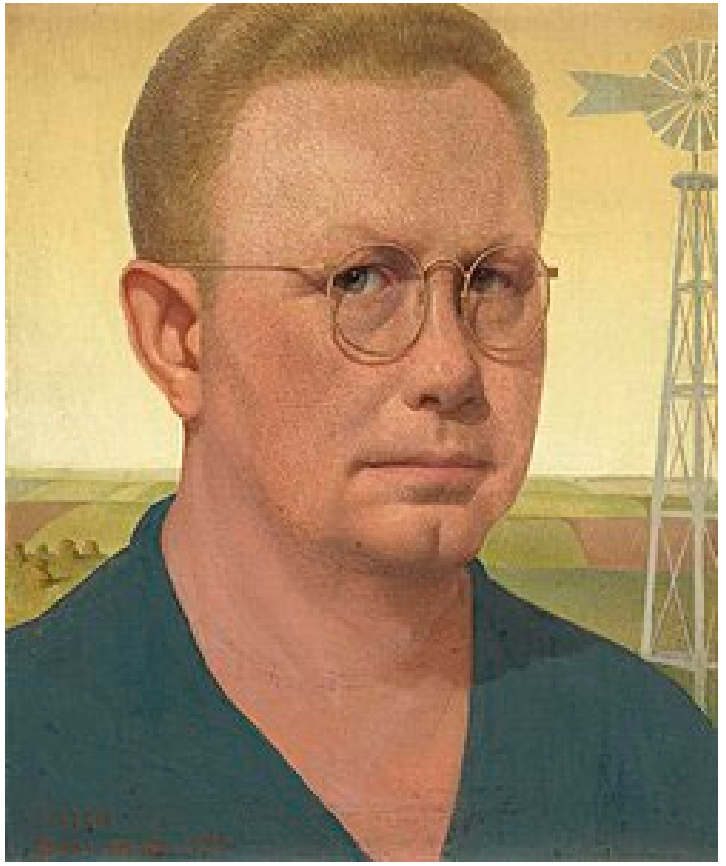
Types of AI in Agriculture

Avian Influenza

Artificial Insemination

Artificial Intelligence

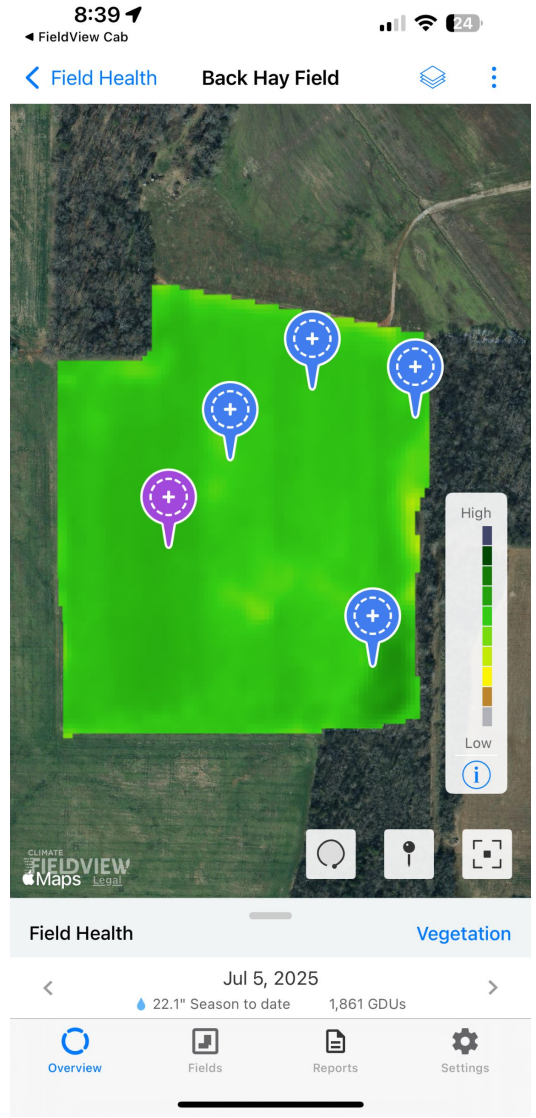


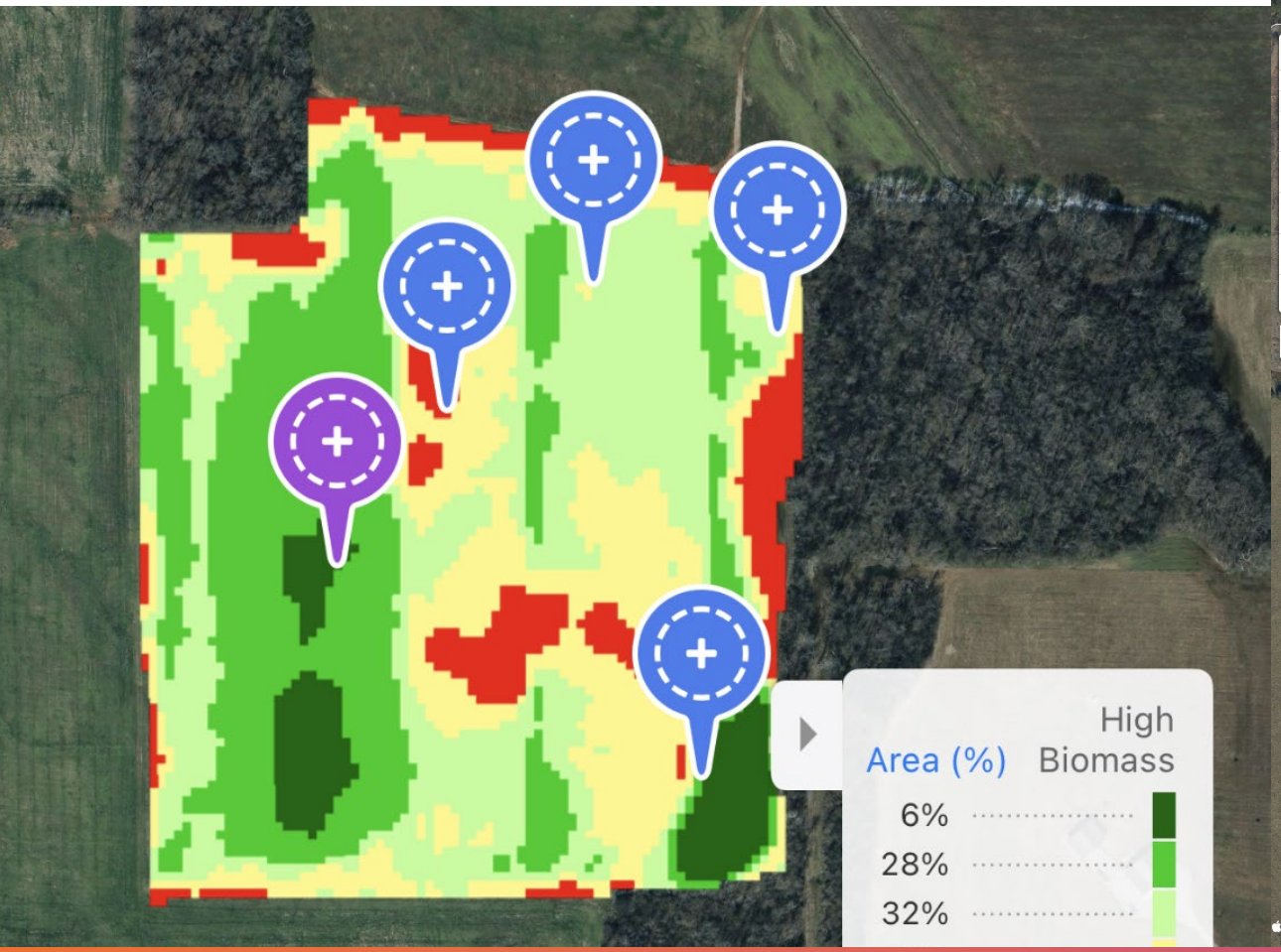


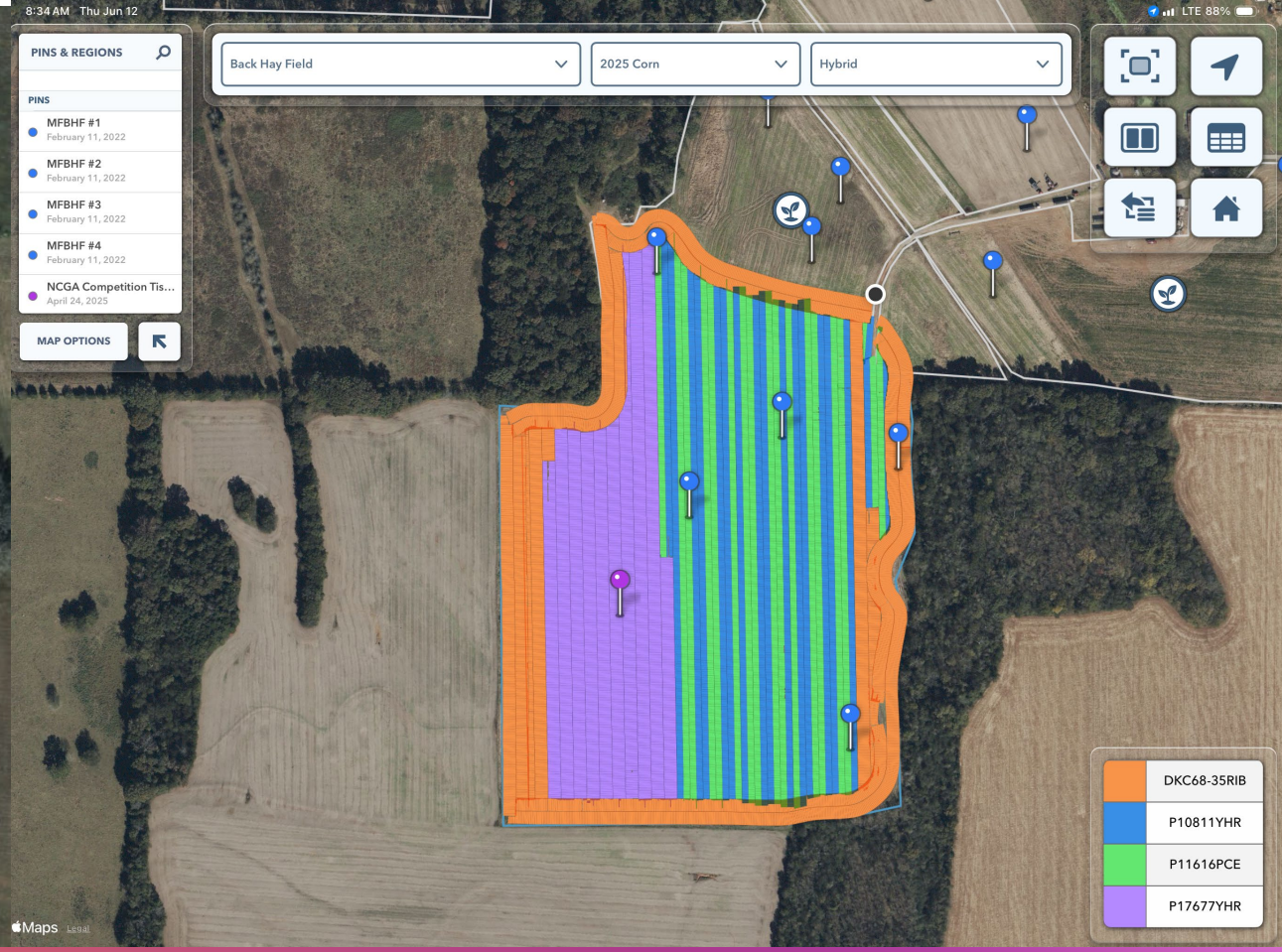
What do you picture when you think about a farmer?

Our Farm

How does our farm utilize Artificial Intelligence?

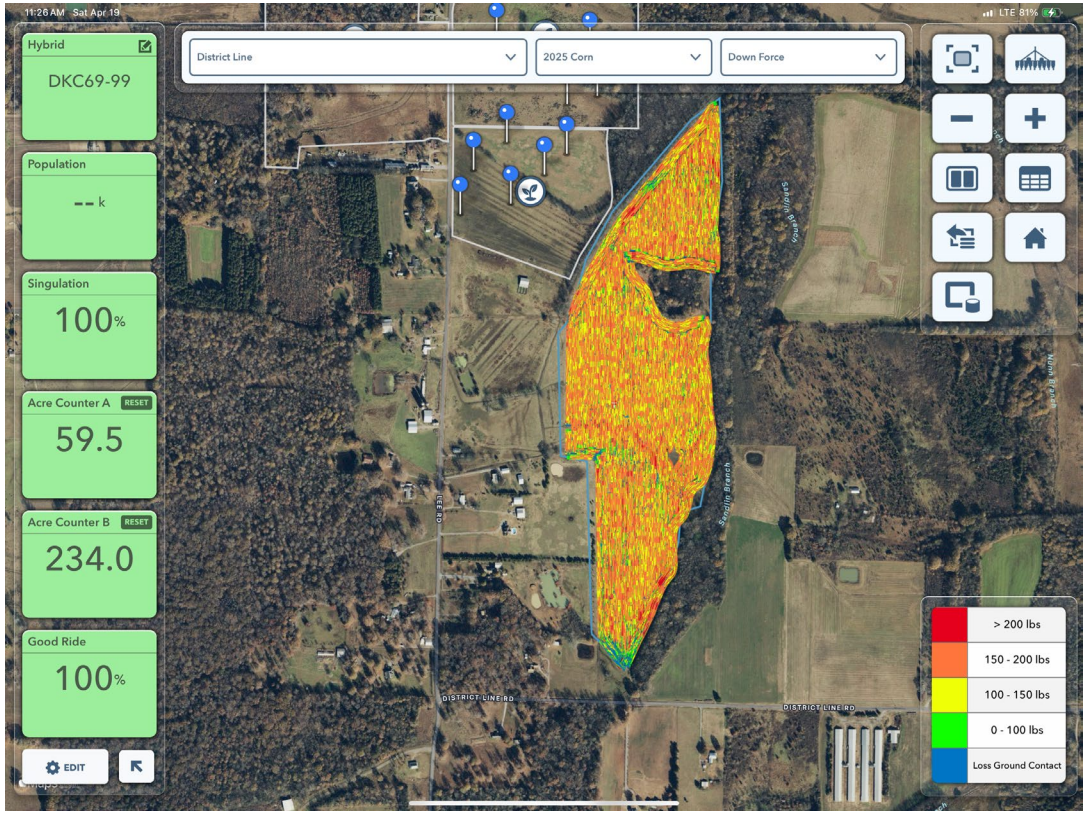






Most recent satellite imagery

Where did that data come from?


11:26 AM Sat Apr 19
LTE 81%
Hybrid
DKC69-99
Population
-- k
Singulation
100%
Acre Counter A
RESET
59.5
Acre Counter B
RESET
234.0
Good Ride
100%
EDIT
District Line
2025 Corn
Down Force
> 200 lbs
150 - 200 lbs
100 - 150 lbs
0 - 100 lbs
Loss Ground Contact
DISTRICT LINE RD
LEE RD
Spring Branch


Variety
P48A14E
Big Field
2025 Soybeans
Population
Acres/Hour
0.0 ac/hr
Acre Counter A
279.5
Acre Counter B
513.5
Good Ride
100%

Additional AI tech testing