https://agaid.org

AI: What it can do, where it is going, and key opportunities for agriculture




Ananth Kalyanaraman
Professor and Boeing Centennial Chair
Director, AgAID Institute, School of EECS

Washington State University, Pullman, WA
Contact: ananth@wsu.edu

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

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

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

NSF

- The AgAID Institute is one of the 29 AI Institutes funded as part of the National AI Research Institute program.
- The AgAID Institute is funded by USDA NIFA.

Unique challenges faced by the specialty crop industry

Water

- Water scarcity and drought
- Region- and season-scale decisions

Status quo: Suboptimal water allocation

Weather

- Weather events can cause severe crop damage and loss (e.g., frost, heat stress)

Status quo: Suboptimal management decisions

Labor

- Increasing production costs, and shortage in unskilled and skilled labor

Status quo: Uncertain and variable profitability

Specialty crops: crop diversity (300+), significant fraction (87%) of U.S. Ag workforce, mostly irrigated high value crops, ~40% perennial systems

We build (Ag AI) tools for:

- Mitigating risks
- Quantifying uncertainty
- Augmenting labor
- Amplifying human productivity
- Fusing scientific knowledge with data
- Predicting the unobservable or the unobserved
- Forecasting
- Testing grounds for exploration
- Interacting and querying

How to make AI work for with agricultural labor?

Intelligent Blossom Thinning and Spraying

Flower thinning to control crop load

Robotic thinning at the WSU Prosser farm

Reuse of robotic platform for intelligent spraying

WSU CPAAS (Karkee et al.) + OSU (Davidson, Grimm)

Intelligent Dormant Tree Pruning

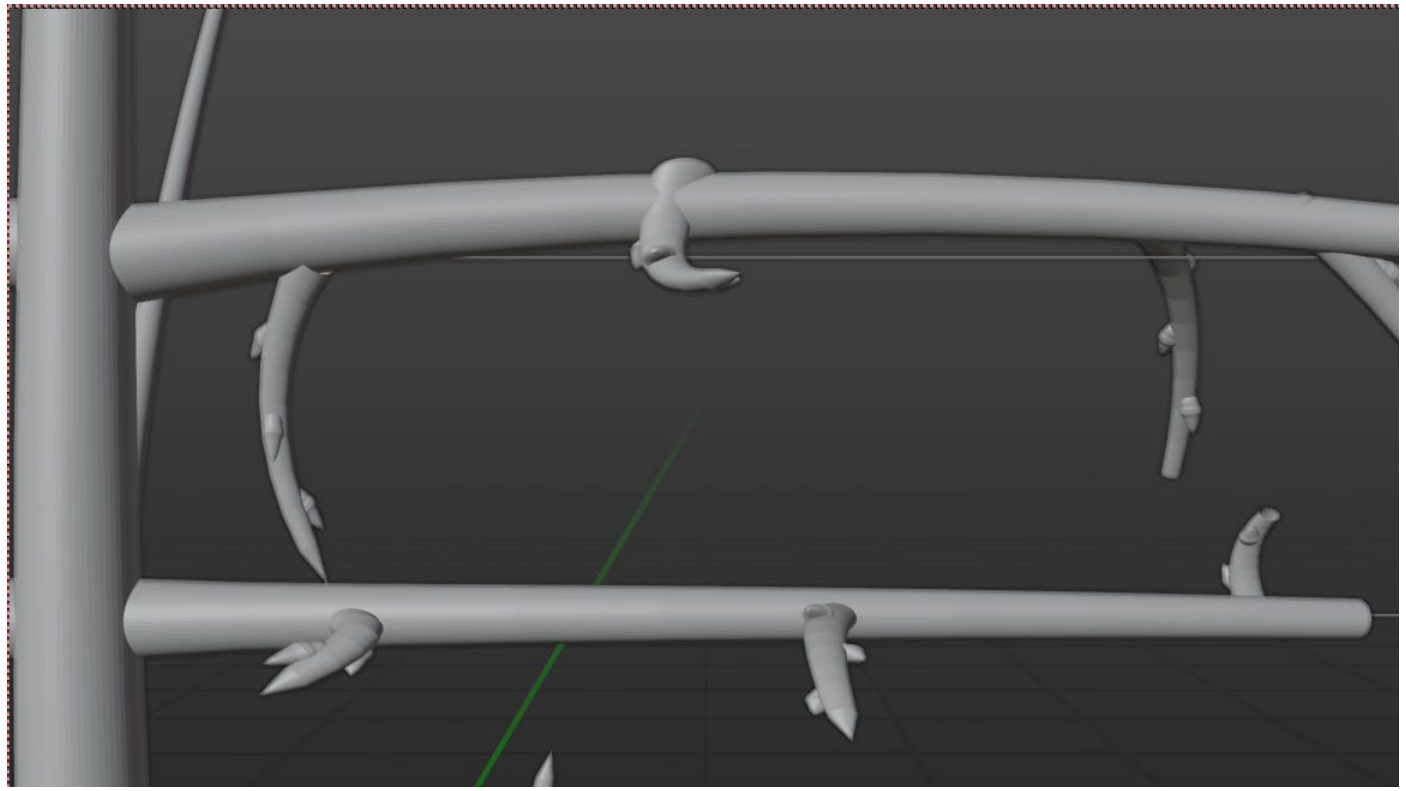
Human (expert) pruner

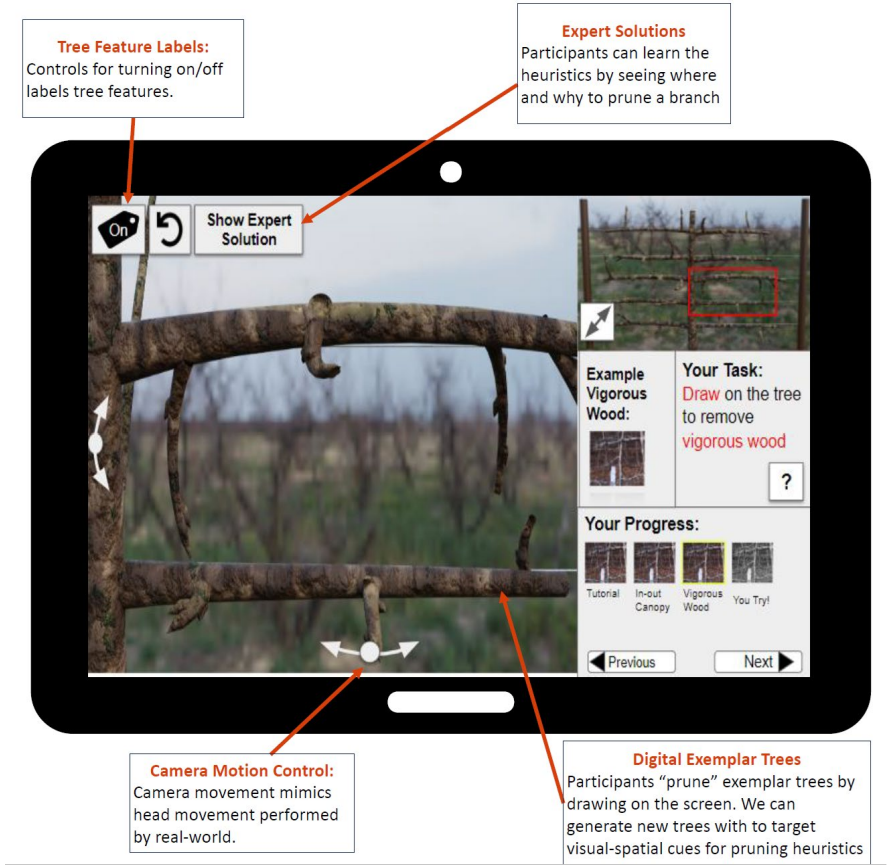
Robotic pruner on the WSU Prosser farm

WSU CPAAS (Karkee et al.) + OSU (Davidson, Grimm)

What would it take for AI and robotics to scale for adoption?

Interactive Pruning Interfaces





Tools at the Human-Machine Interface

AI to
model crop risks due to abiotic stresses

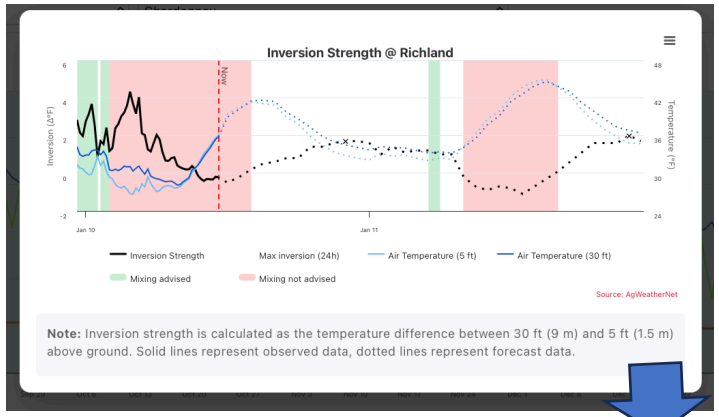
Frost Mitigation in Fruit crops

Sweet Cherry

Grape

Blueberry

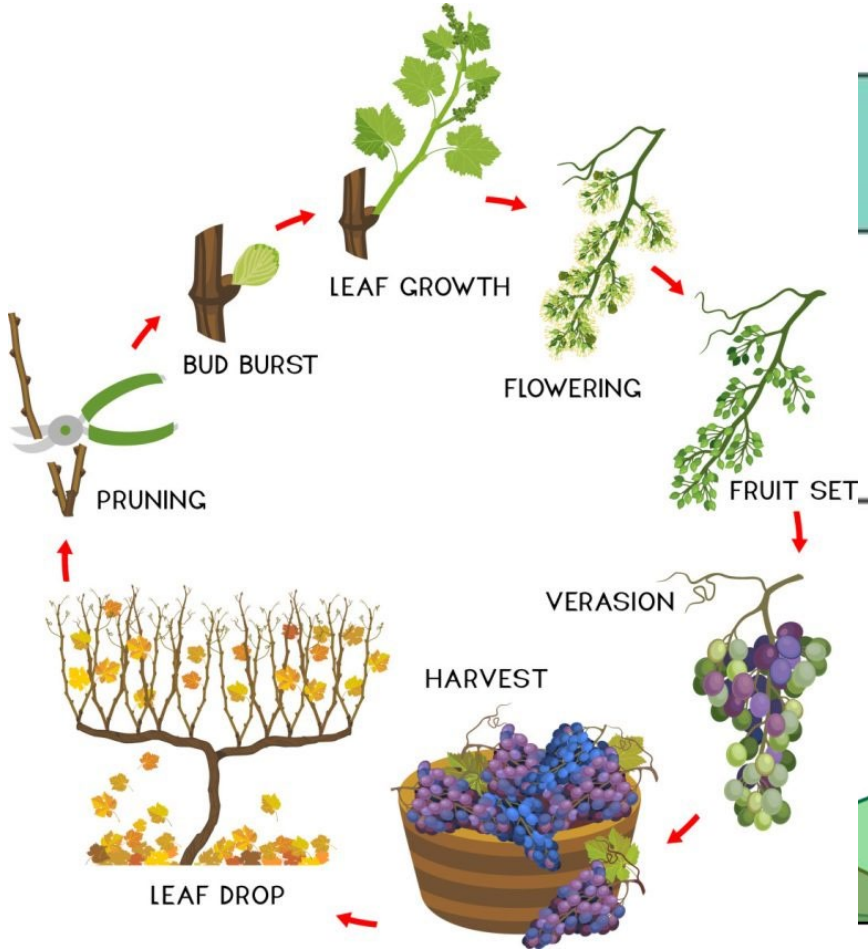
Blackberry

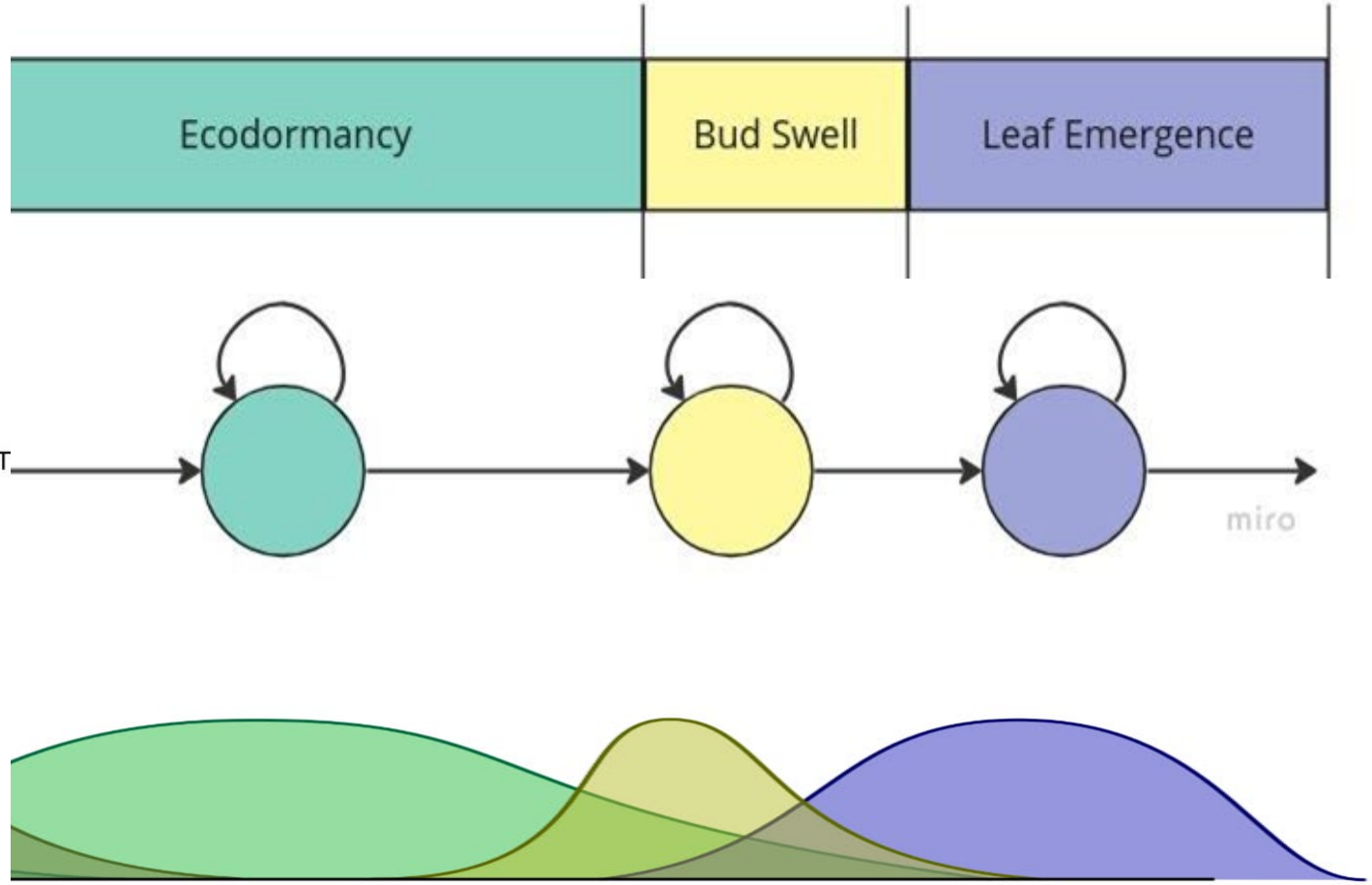


<u>Team:</u> L. Khot, M. Keller, P. Pesantez, G.-A. Hoheisel (WSU), A. Fern (OSU), and AgWeatherNet

AI can also help with seasonal planning

AI for tracking and forecasting crop development stages

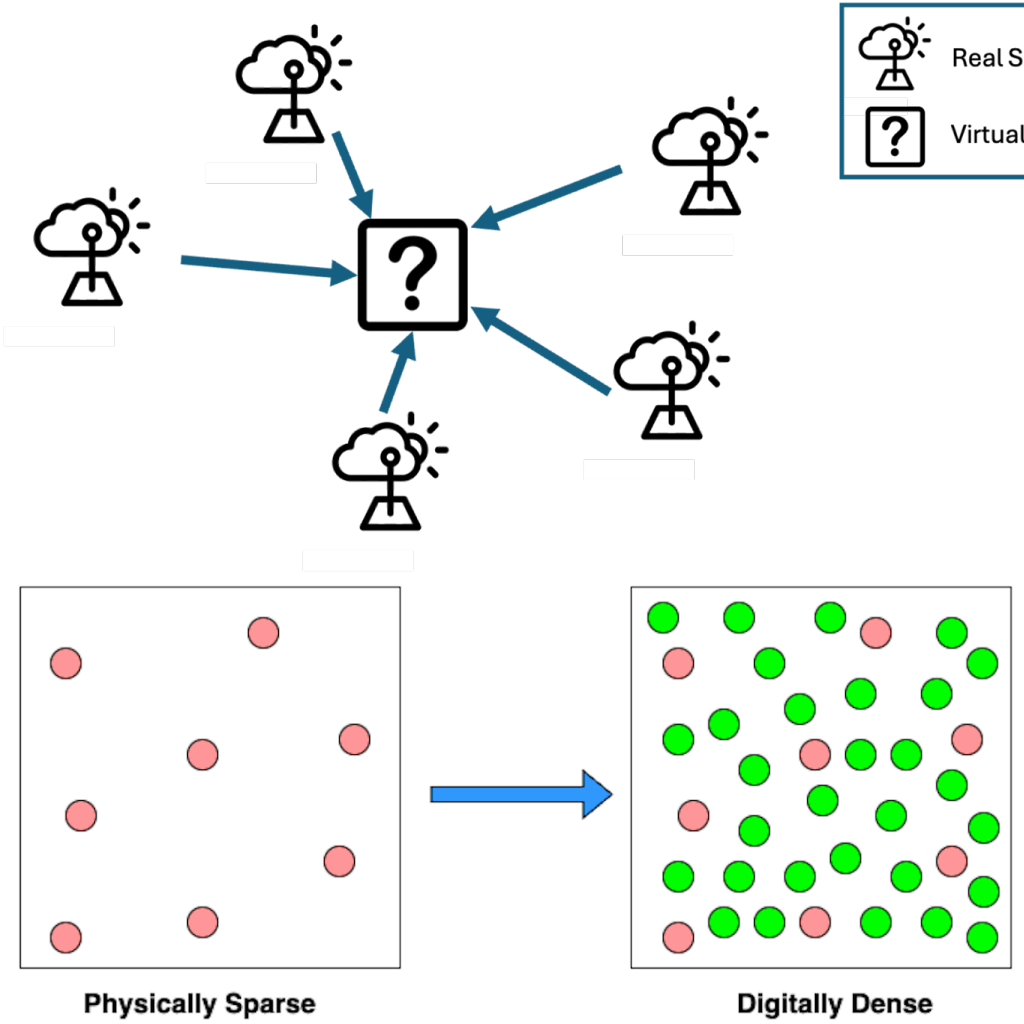


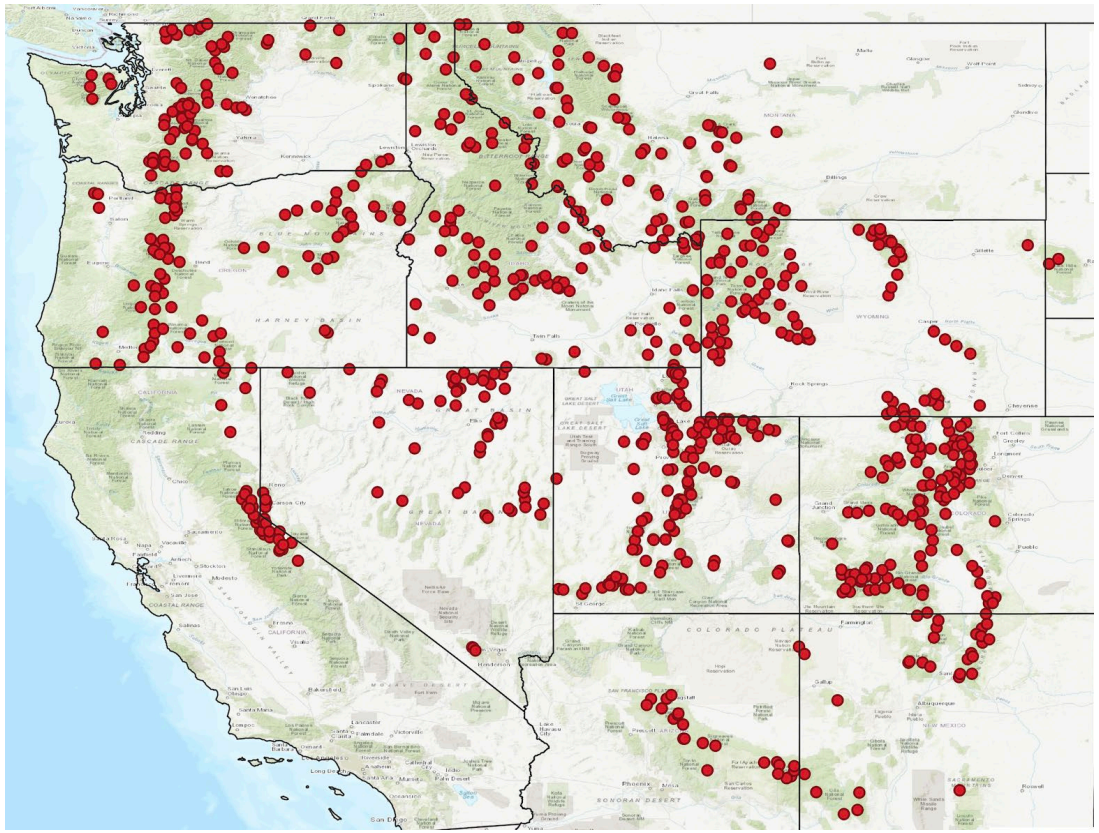


Balcarcel, Kalyanaraman, Keller, Pesantez (WSU)

AI can help with filling in missing data or unobserved data

Spatial imputation (for snow & weather)





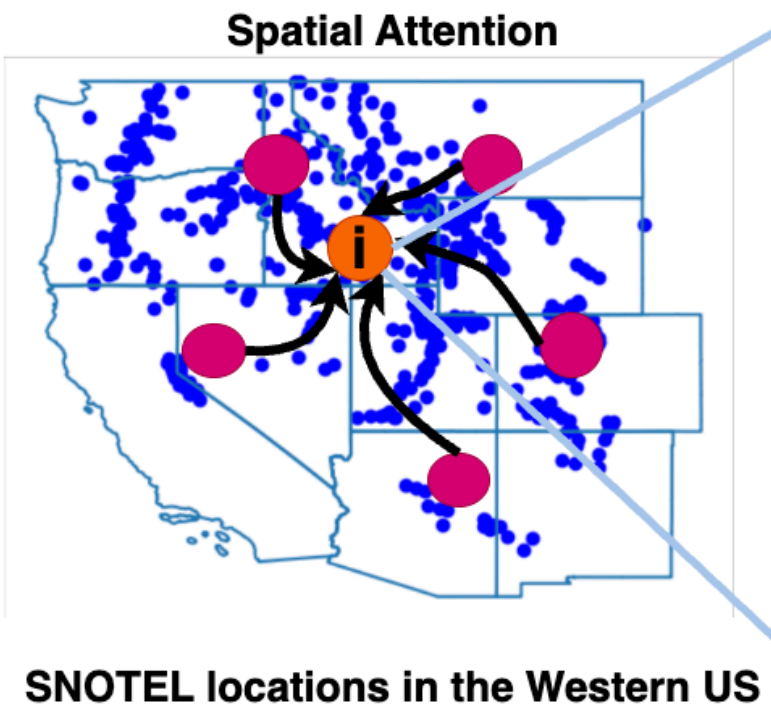
Thapa, Singh, Savalkar, Rajagopalan, Kalyanaraman [AAAI'24]

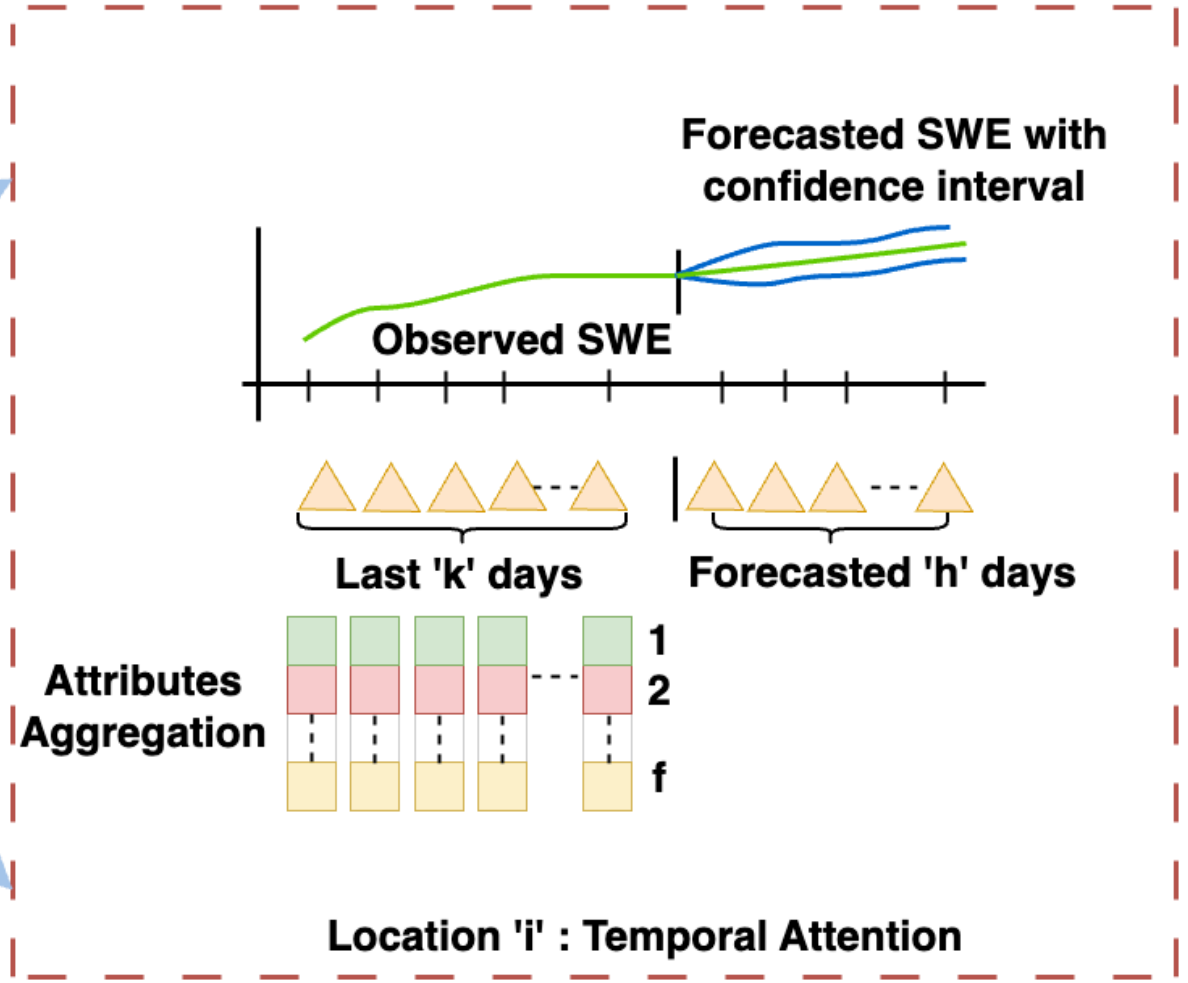
AI can help
quantify uncertainty in decision making

SWE Forecasting Under Uncertainty

Key question:

Can we forecast for a forecast horizon of h days?
(with uncertainty quantified)



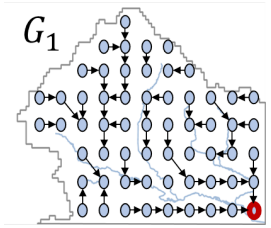


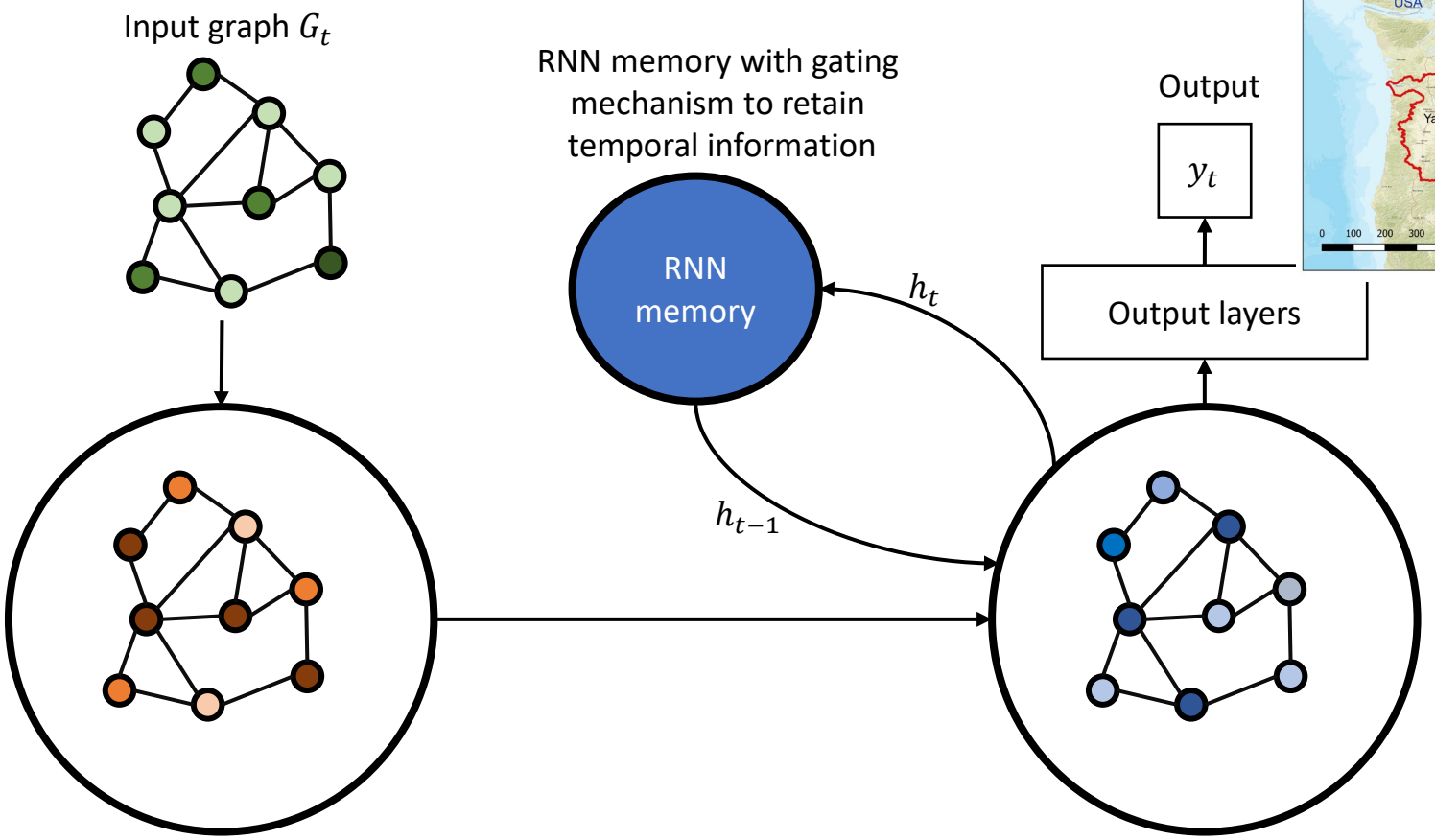
Thapa, Singh, Savalkar, Rajagopalan, Kalyanaraman, AAAI'26

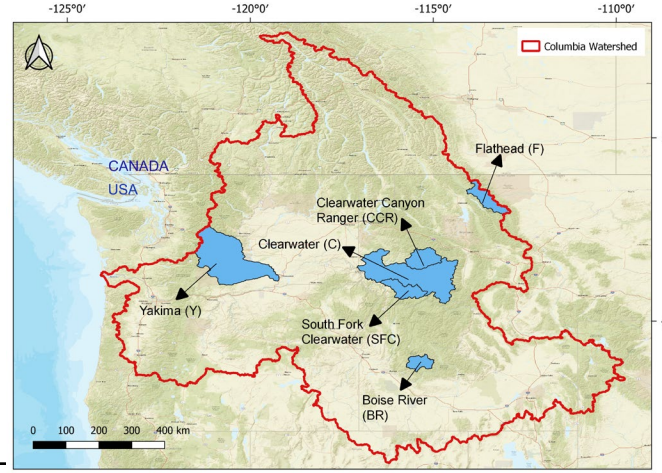
AI can help with

fusing data with scientific knowledge

Modeling Streamflows with Physical Constraints







Gharsallaoui, Doppa, Rajagopalan, Savalkar, Singh, IJCAI'24

AI interfaces for querying knowledgebases

POTATOES & PESTS

PAPAS

Actionable Science Against Nematodes

What are the drivers that lead the potato cyst nematodes (PCN) percentage of viability to 0?

USER INTERFACE (UI/UX)

Query process

Search & Retrieve

Relevant information

Knowledge Base

Retrieval-Augmented Generation System

Modality-Centric Retrieval

Similarity-Search Retrieval

MIPS-Variants

Re-ranking Strategies

Top-K Images

Augmentation

Context Enrichment

Adaptive/Iterative Retrieval

1) Lack of Host Plants. 2) Environmental Conditions. 3) Soil Type and Management Practices. 4) Biological Control Agents. 5) Chemical Control. 6) Cyst Age and Condition. 7) Host Resistance

Sources 100 |

Large Language Model

A Chatbot for potato nematode researchers and extension scientists

...

Pesantez, Kalyanaraman, Zasada, Dandurand

AI-ready testbeds can help with:

transfer of technology to different systems, and

transition from research to practice

Smart Orchards and Demo Farm: AI-ready Test beds

WSU-ROZA Farm (5 Miles North of Campus)

Apples: 0.3 ha

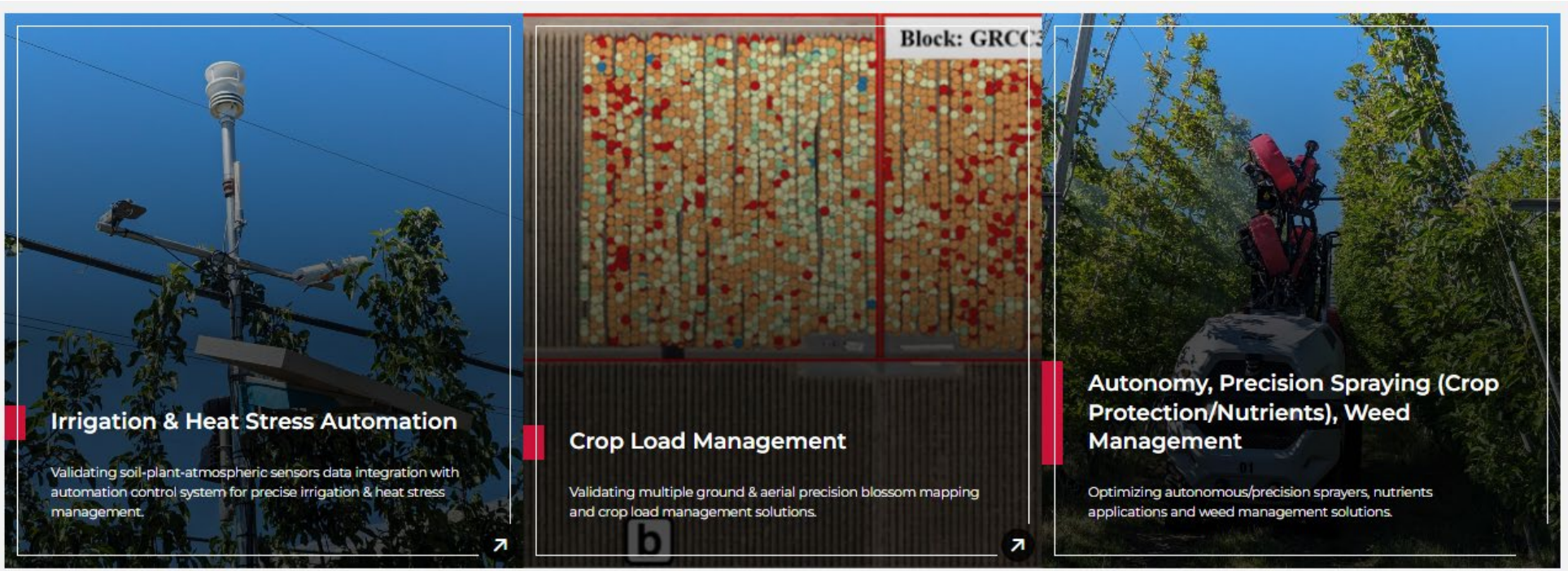
Grapes: 0.2 ha

Smart Apple Orchard Testbeds (Mattawa, WA; Zillah, WA)

Technology Testbed & Demo Site

WSU Smart Apple Orchard

Automated precision orchard management technologies evaluation & grower education



PIs: Khot, Sallato, Mantle, Peters, Kalyanaraman

Researchers: S. Gorthi, D. Bhalekar, J. Munguia, P. Medarametla

Public-Private Partners (30+)

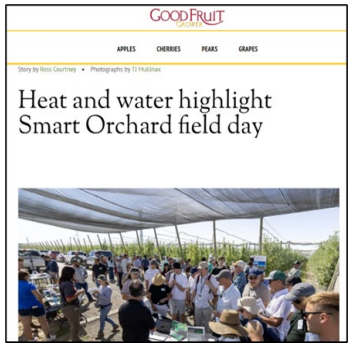
Extension and education are key to ensure transition to practice

Experimental Community Learning Sites

K-12 MESA
Environmental Sensing

K-12 MESA
Drones in Agriculture

Grower Education



2025 Field Day
Precision & Automated Irrigation Systems

The Road Ahead

AI foundations

Early demonstrations in agriculture

We are here

Pervasive AI in Ag (Farm to Table)

Generative AI and Ag foundation models for specialty crops

Establish AI-ready experimental testbeds and data consortia

Cybersecurity and privacy

Responsible scaling plan for labor and automation

AI-ready workforce

Challenges and Opportunities

- **Model generalizability vs. site-specificity**
  - Transfer learning
  - Test-time learning and adaptability
- **Human-AI interfaces**
- **Data and model commons**
  - Data consortia, standards
- **Trustworthiness**
  - Privacy and cybersecurity
  - AI literacy and awareness
- **Bringing up adoption rates**
  - Scale-neutrality
  - Translational AI emphasis
- **Workforce preparedness**
  - Responsible scaling plan
  - Ethical AI
- **Shrinking federal funding**

➔ **The Path Forward**

- Academia-private-public partnerships
- Regional partnerships are the key
  - Regional innovation hubs
  - Rural community involvement

A future worth building together

It is our moral imperative to build and secure the future of our farming and rural communities

- Imagine a future where:
  - Every **farmer** has a digital twin of their farm/orchard to reliably evaluate different strategies for the season and account for different uncertainties
  - Every **worker** comes to the farm knowing their skills are valued and their productivity amplified through technology (without feeling threatened)
  - Every **regional policy maker** can plan infrastructure and land use pattern with quantified uncertainties
  - Every **kid** growing up in rural America can have an opportunity to build a career in Ag-Tech and AI, and bring those hitech jobs to the rural communities

Thanks for the support!

Special thanks to WSAS for organizing this series!

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https://agaid.org/partners/

Tree fruit and grape industry & Growers, WA Tech Industry partners (Microsoft), Irrigation districts, Educational partners, Partners in Oregon, ID, CA, VA

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