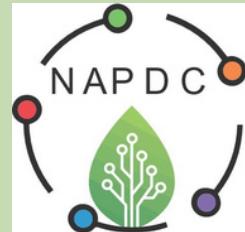


# 2025 ANNUAL MEETING IMPACT REPORT

November 9-12 2025  
Salt Lake City, UT



## National Agricultural Producers Data Cooperative

*Designing a Strategic Framework for Increasing Production and Driving Innovation*



# NAPDC ENGAGEMENT

## Poster Presentation:

### Tree of Tables (ToTs): Model for Agricultural Data Interoperability

Dr Yaghuang Zhang, Purdue University

**Tree of Tables (ToTs): A Pragmatic Model for Achieving Long-Term Interoperability in Global Agricultural Data**

 **Yaghuang Zhang**

What is a Maximally Interoperable Model? The key missing element in interoperability definitions is the recognition that it is a **sentiment held by the people involved**.

$$\text{MIM} = \text{FIM}(\text{I}) = \sum_{i=1}^n \text{C}(i) + \sum_{i=1}^n \text{P}(i, j, k) \cdot \frac{\text{C}(i)}{\text{C}(j, k)} \cdot \left( \frac{\text{C}(j)}{\text{C}(i, j)} \right) \cdot \left( \frac{\text{C}(k)}{\text{C}(i, k)} \right)$$

A MIM is a model that maximizes  $\Delta I$ .

**Agriculture's Key Distinction: Time**

$C_0^{1 \times 0}$	$C_1^{1 \times 0}$	$C_2^{1 \times 0}$	$\dots$	$C_n^{1 \times 0}$	$\dots$	$[C]^1 \times 0$
$C_0^{1 \times 1}$	$C_1^{1 \times 1}$	$C_2^{1 \times 1}$	$\dots$	$C_n^{1 \times 1}$	$\dots$	$[C]^2 \times 1$
$\dots$						
$C_0^{1 \times T}$	$C_1^{1 \times T}$	$C_2^{1 \times T}$	$\dots$	$C_n^{1 \times T}$	$\dots$	$[C]^{T+1} \times T$

This highlights a frustratingly critical requirement of a MIM: it is heavily biased toward the "new". Anything "new" which solves a problem of today cannot easily overcome the proven history of staying power from the "reliable".

**Cloud and API Friendly**  
Soil-lab data uses Modus standard in ADC:

- Name
- OATS Center at Purdue University
- IoT
- Trelis
- IoT4Ag
- Soil
- Conductivity
- Temperature
- Water content
- Lab results
- Soil

 [Maximally Interoperable Models \(MIMs\): A Heuristic Approach for Evaluating Interoperability](https://github.com/oats-center/modus)  
<https://github.com/oats-center/modus>



**ToTs Basics**

CSV Serialization: everyone can read these. Since the 1990's.

Standardized "Logical Geography" => folder structures: everyone can store/transfer/zip folders. Inherent  $O(\log n)$  indexing.

Ambient Context: location in tree informs types, units, schemas.

Widespread common tooling: Excel, Tableau, PowerBI, AI data analysis tools.

Language independence: nearly all programming languages can directly utilize ToTs.

AI-Ready: ToTs is an ideal format for data ingestion and inference for LLMs and other AI tools since it carries inherent human-interpretable structure.

**Acknowledgments**

This work was also funded in part by USDA AFRI grant 2021-77039-35992, and in part by USDA NIFA grant 2024-77039-43724, Subaward No. 25-6231-04500, through the NAPDC and the University of Nebraska-Lincoln to the Open Ag Technology and Systems (OATS) Center at Purdue University.

Yaghuang Zhang, Aaron Ault



**Tree of Tables (ToTs)** is a practical, future-proof way to make **ag data** interoperable—today and **decades from now**.

It can be made to work on nearly every common platform, is accessible to both laymen and machines, and will likely be accessible for decades to come.

**ToTs** is one of the best **Maximally Interoperable Models (MIMs)** for data in agriculture.

In recent work on Maximally Interoperable Models, interoperability is a human-centered property: data are truly interoperable when the time, effort, and specialized knowledge required to use them are minimized for the widest range of current and future users and systems. In agriculture, where decisions span seasons to decades, models also need "staying power".

To meet this need, the Open Ag Tech & Systems (OATS) Center developed Tree of Tables (ToTs): a simple but rigorous way to publish data as spreadsheets/CSVs (the leaves) organized in a clear folder hierarchy (the tree). The structure carries "traveling context" with files and "ambient context" in the folder structures, making data both human-legible and machine-ready.

Over the past year, the team has created an open-source Modus→ToTs conversion pipeline with Shapefile and GeoJSON support and a merge utility that links lab results to sampling locations. We are building a browser-based soil-health prototype (map + time-slider) that lets producers explore trends in soil properties over time while keeping their data in their own platforms.

## Exhibitor Booth: NAPDC in collaboration with GOAT

Gathering for Open Ag Technology is a collective that aims to coordinate existing development in the ag data space, invite new development, align technology and actual users and create a collaborative roadmap.

Different organizations such as NAPDC, Point Blue Conservation Science, The Soil Inventory Project, Terraso, University of British Columbia, etc have come together to address key challenges in the open-source development area such as data sharing, inter-operability, closed data ecosystems, etc. The shared booth showcased informational materials, handouts and interactive displays explaining the open ag tech landscape, current gaps and our collective vision. We also invited conference attendees to share challenges, solutions and connected with partners actively building the future of open ag technology, in the spirit of networking and dialogue.





## NATIONAL AGRICULTURAL PRODUCERS DATA COOPERATIVE



**About Us**

To create innovative, data-driven agricultural production systems, producers will need access to their own data, simulations, forecasts, and modeling to improve the way they can run their operations to yield enhanced sustainability. Our goal is to gather essential information needed to inform a cross-domain and cross-community data framework that can support a "grower data lake" across diverse national and regional agricultural systems.

**Our Objectives**

- ✓ Develop a blueprint for a National Agricultural Producers Data framework
- ✓ Engage and support diverse participation
- ✓ Communicate and disseminate findings



AG DATA REPOSITORY



DATA FRAMEWORK



SATELLITE IMAGERY

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