

Climate Data Analytics Project

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(Mastery Project, Masterschool)

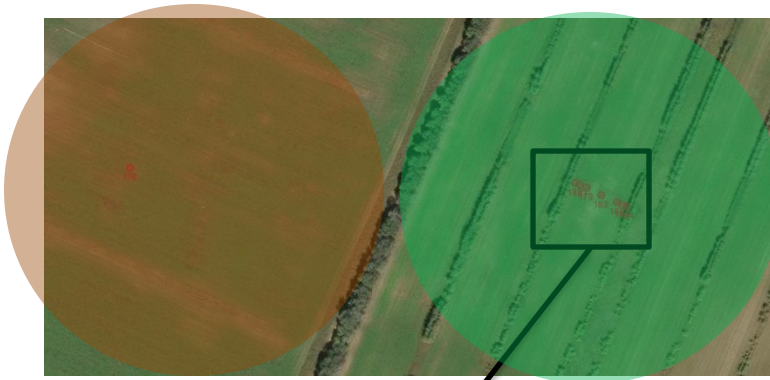
# The foundation - AgroForest

- The foundation studies sustainable agricultural practices, focusing on agroforestry systems.
- Agroforestry integrates trees and crops to enhance biodiversity, improve soil health, and mitigate climate risks.



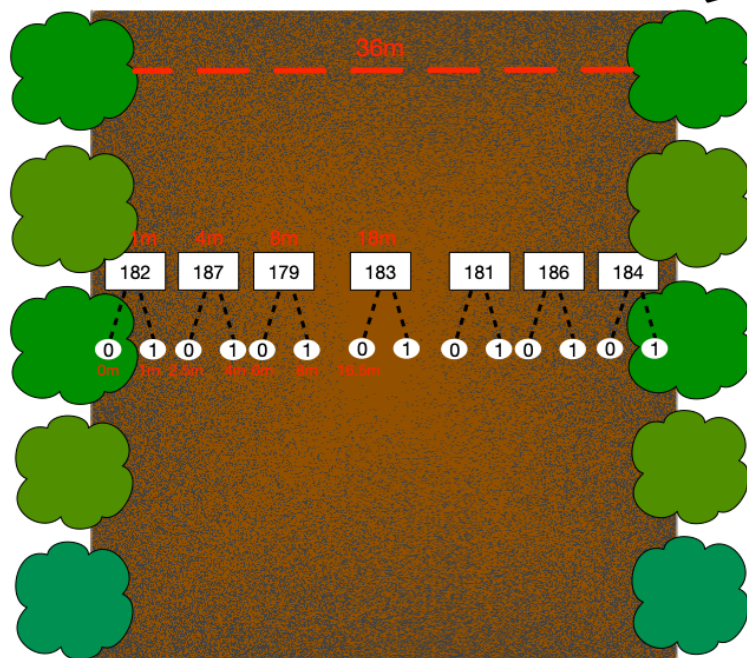
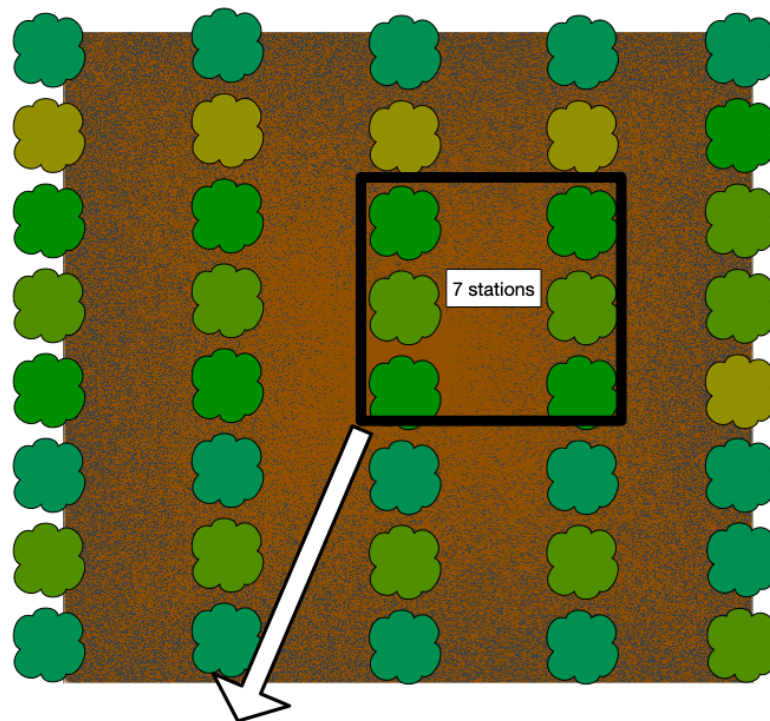
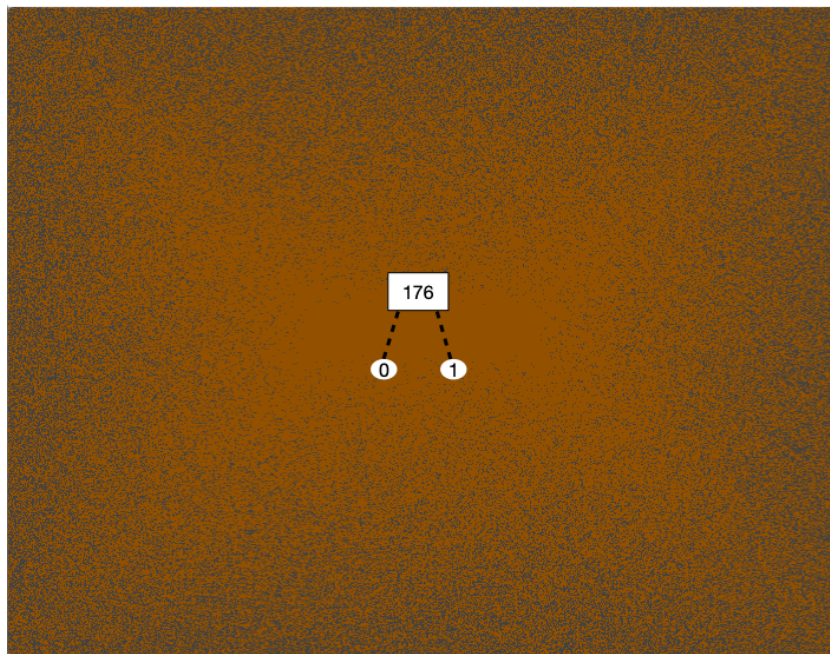
# Climate Data

- The climate stations provide continuous data that allow comparison between:
  - Open fields (without trees).
  - Agroforestry fields (with tree rows)



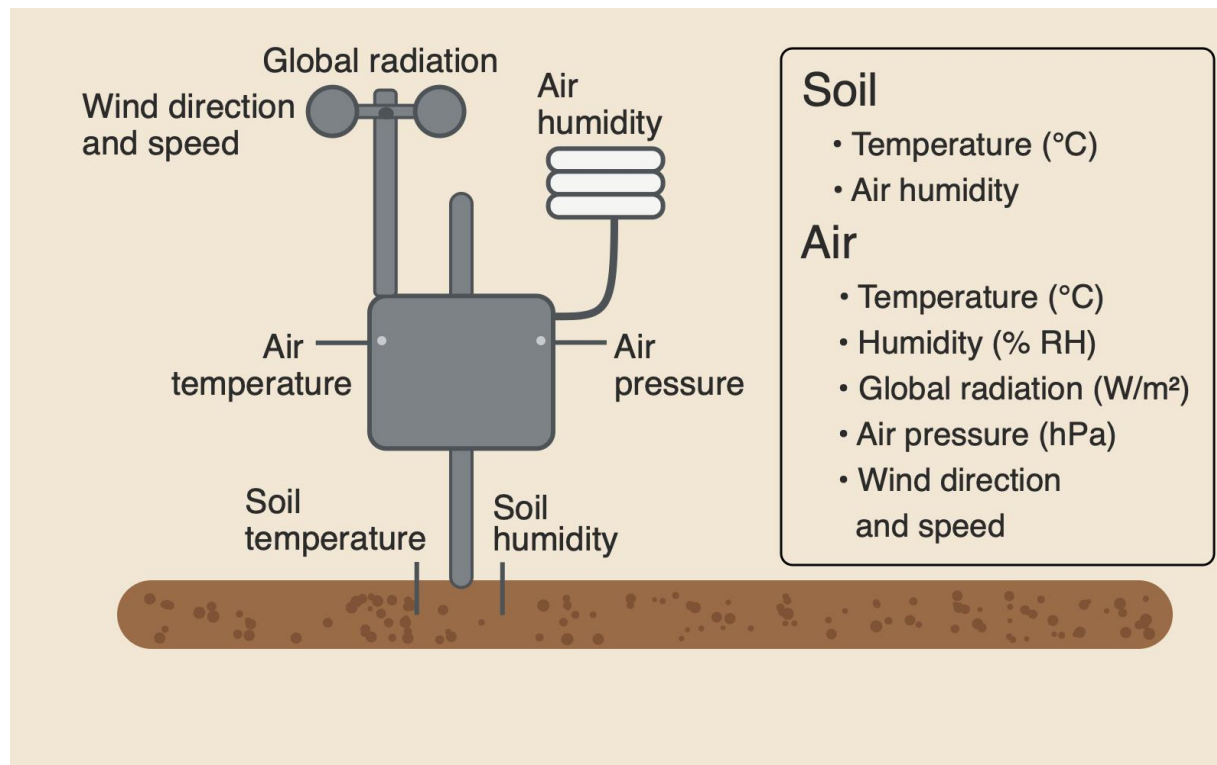
ground level ————  
35 cm below ground ————





# Dataset Context

- Climate station sensor data, recorded across multiple nodes in different field conditions.
- Timestamped measurements (15 min steps)



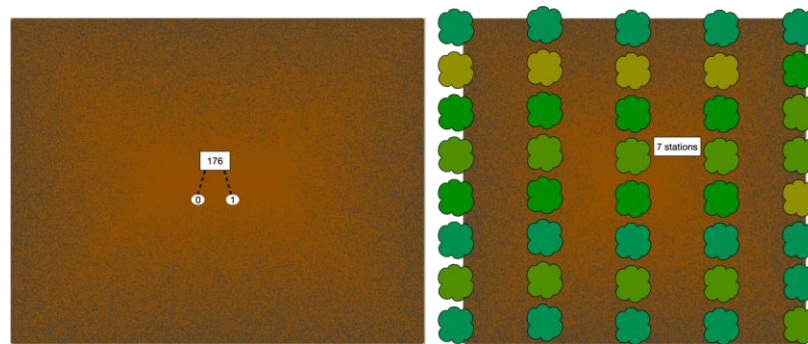
# Retrieving/Querying Data

- Sensors transmit 15-minute data to a secure dashboard I can access.
- Raw data are available for download as CSV files.



# Key Research Questions

1. Does the agroforestry field differ significantly from the open field in terms of microclimatic and soil conditions?



## Soil

- Temperature (°C)
- Air humidity

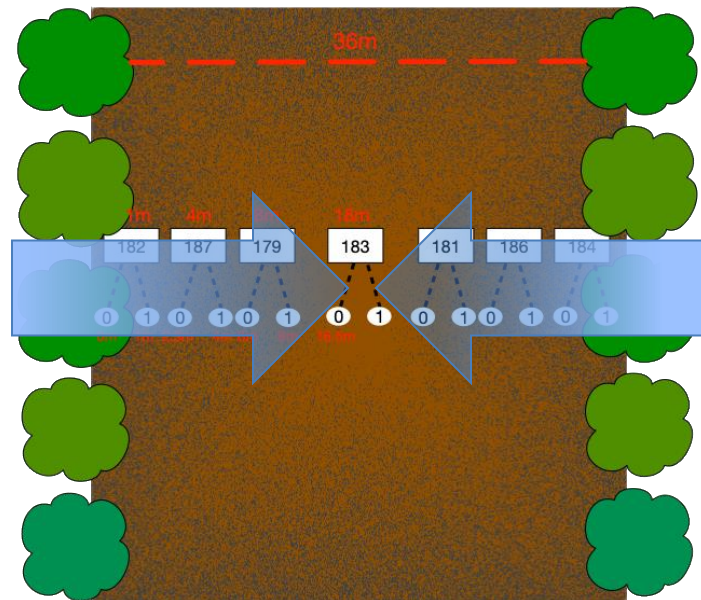
## Air

- Temperature (°C)
- Humidity (% RH)
- Global radiation (W/m<sup>2</sup>)
- Air pressure (hPa)
- Wind direction and speed



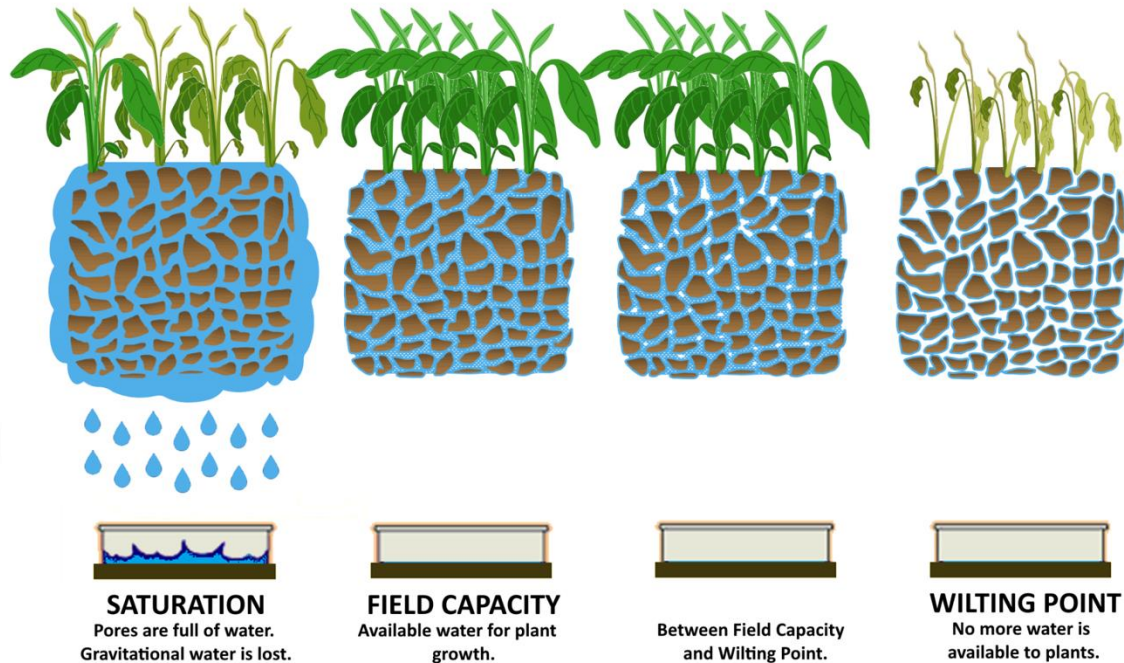
# Key Research Questions

2. Are significant differences observed between sensor points placed at varying distances from the tree rows within the agroforestry system?



# Key Research Questions

3. How does the development of soil moisture over time relates to the Permanent Wilting Point (PWP\*)?

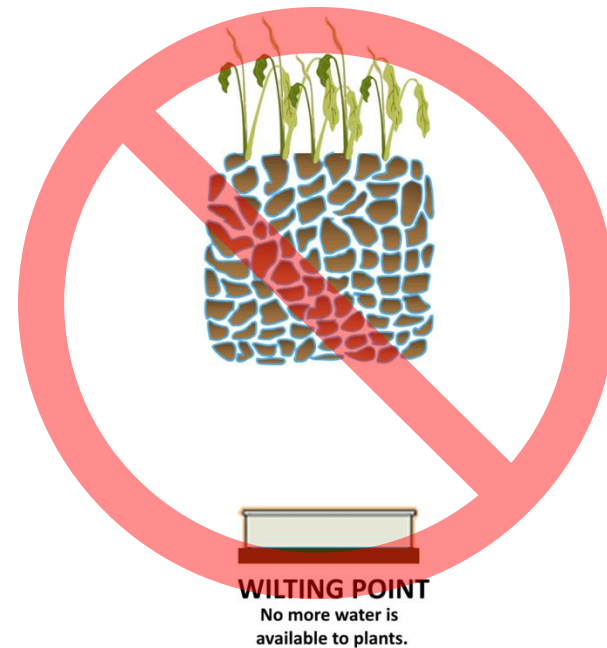
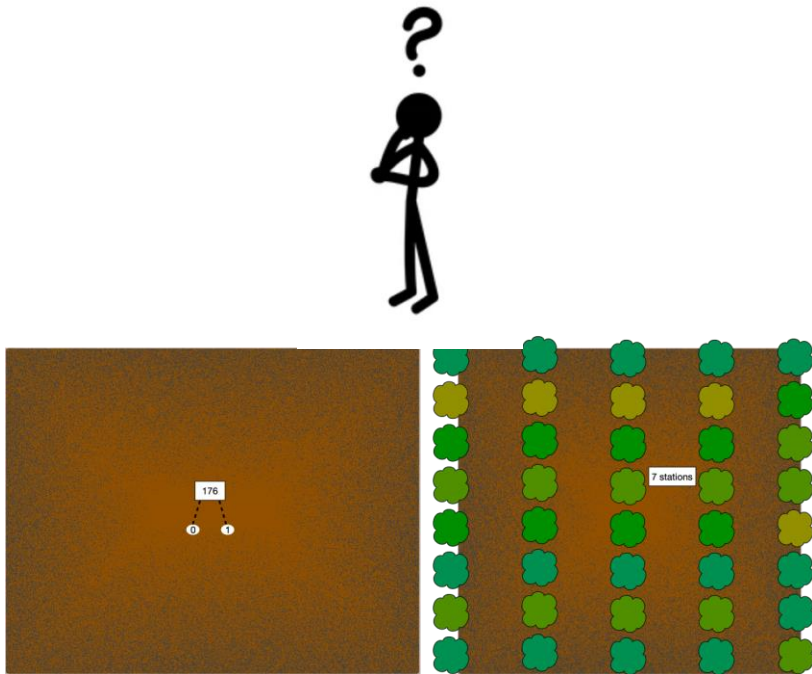


\* The Permanent Wilting Point is defined as the soil moisture content at which plants can no longer extract sufficient water to meet their physiological needs.

Pic: <https://connectedcrops.ca>

# Key Research Questions

4. Can agroforestry practices mitigate the risk of soils reaching critical levels of dryness?



# Key Research Questions

5. To what degree can missing sensor data be reliably interpolated without compromising analytical accuracy?



# Variables - Consequences

Temperature ->



## Soil

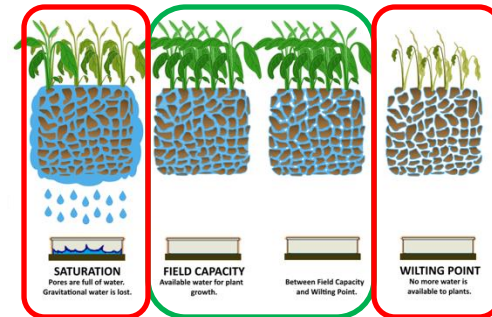
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- Temperature (°C)
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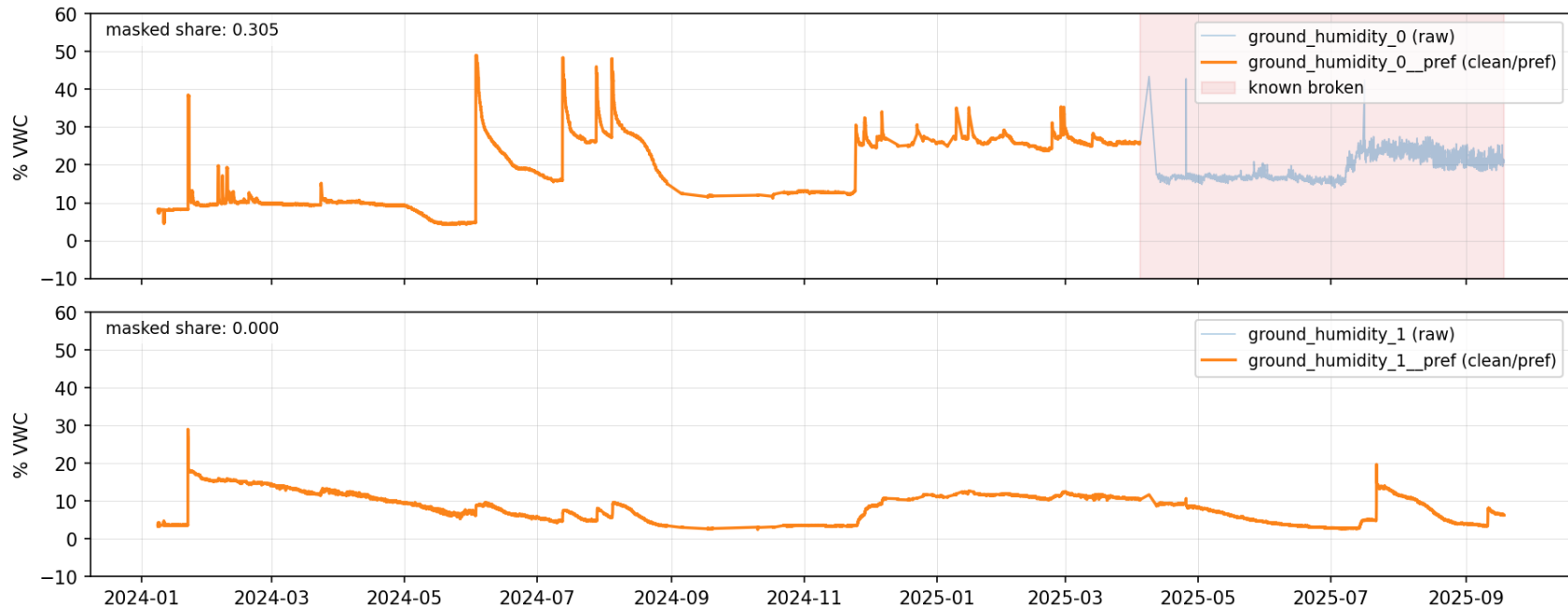
Humidity ->



Radiation -> carbon gain, water loss, developmental timing

# Cleaning the data

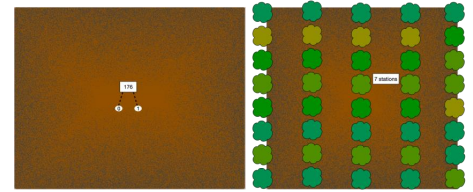
Soil moisture — node\_184



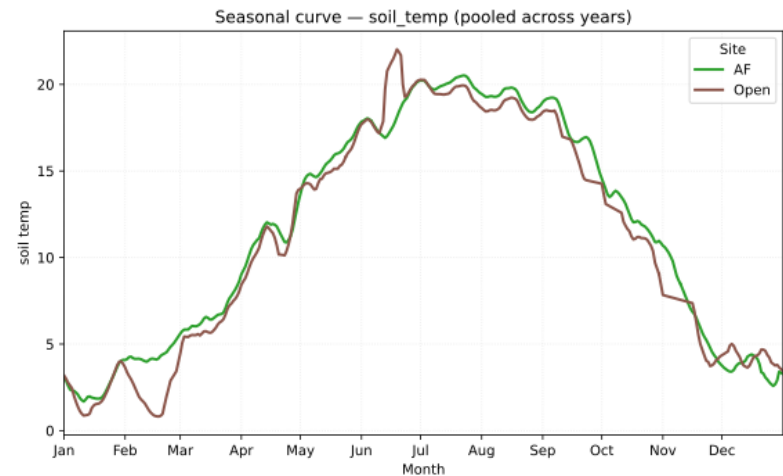
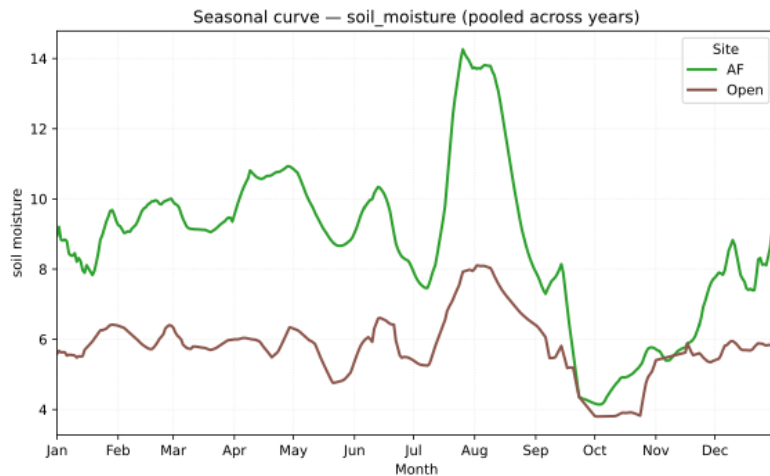
# Feature Engineering

- **Daily, node-equal summaries** — one value per node per day so no single sensor dominates.
- **Combine the two soil probes** — average per node to reduce noise and represent the root zone.
- **Geometry features** — distance to tree row, left/center/right, and across-alley position (row→middle→row).
- **Season tagging** — month/season to read effects when plants actually need water.
- **VPD** — engineered from temperature + humidity to capture the air's drying power (transpiration demand).
- **PWP thresholding** — set a wilting threshold (lab, texture model, or retention curve) and flag days below it.
- **Risk metrics** — site-day risk = share of nodes below PWP; plus longest dryness spells by distance.
- **Gradient diagnostics** — step contrasts (1→4, 4→8, 8→16.5 m) and within-day slopes to quantify strength/direction.

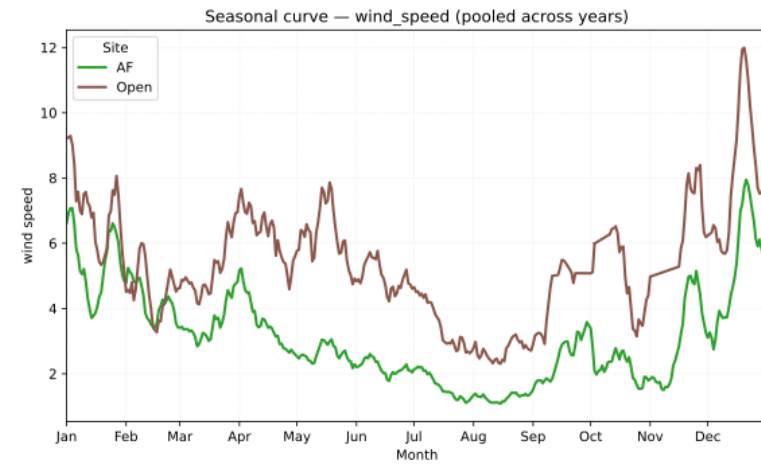
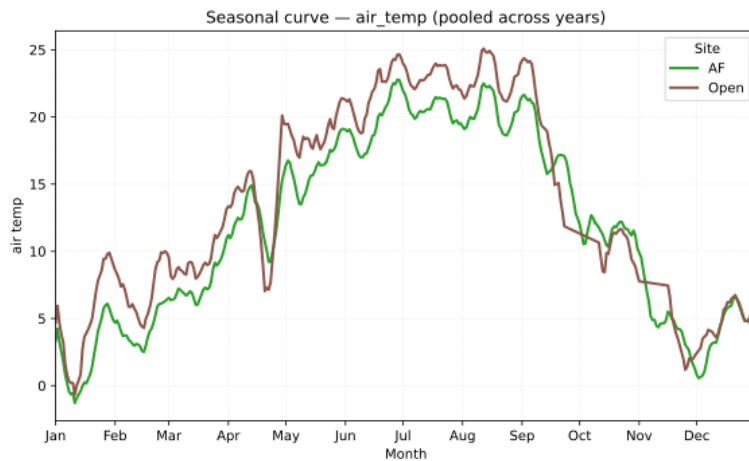
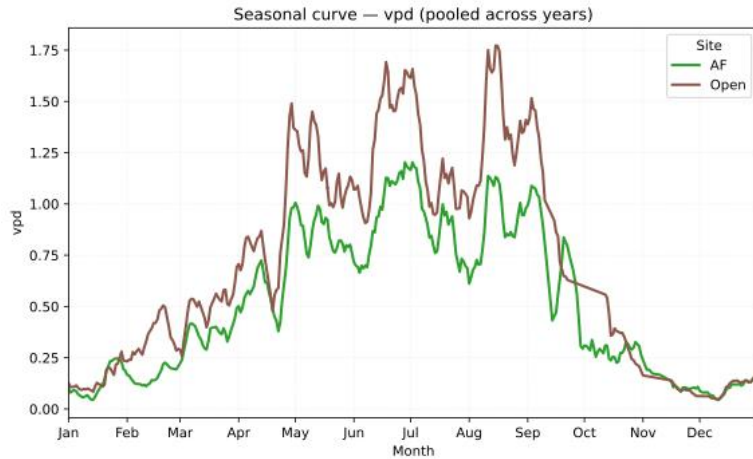
# Results Q1



1. Does the agroforestry field differ significantly from the open field in terms of microclimatic and soil conditions?

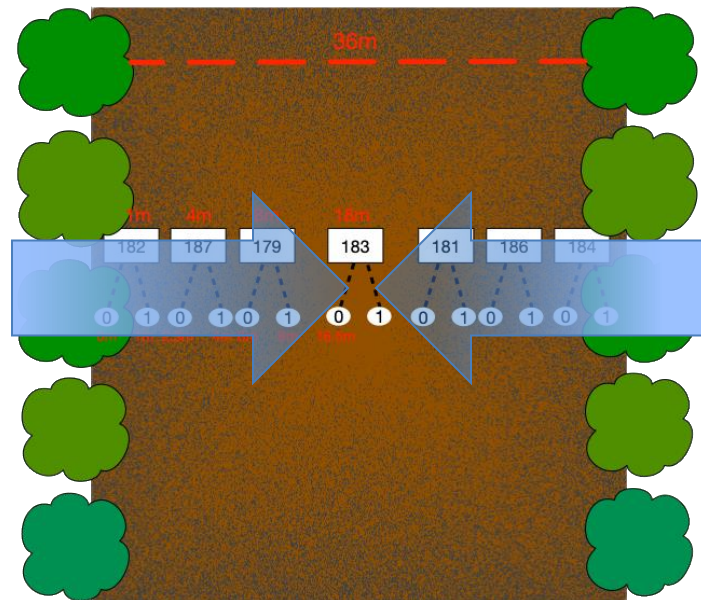


# Air measures

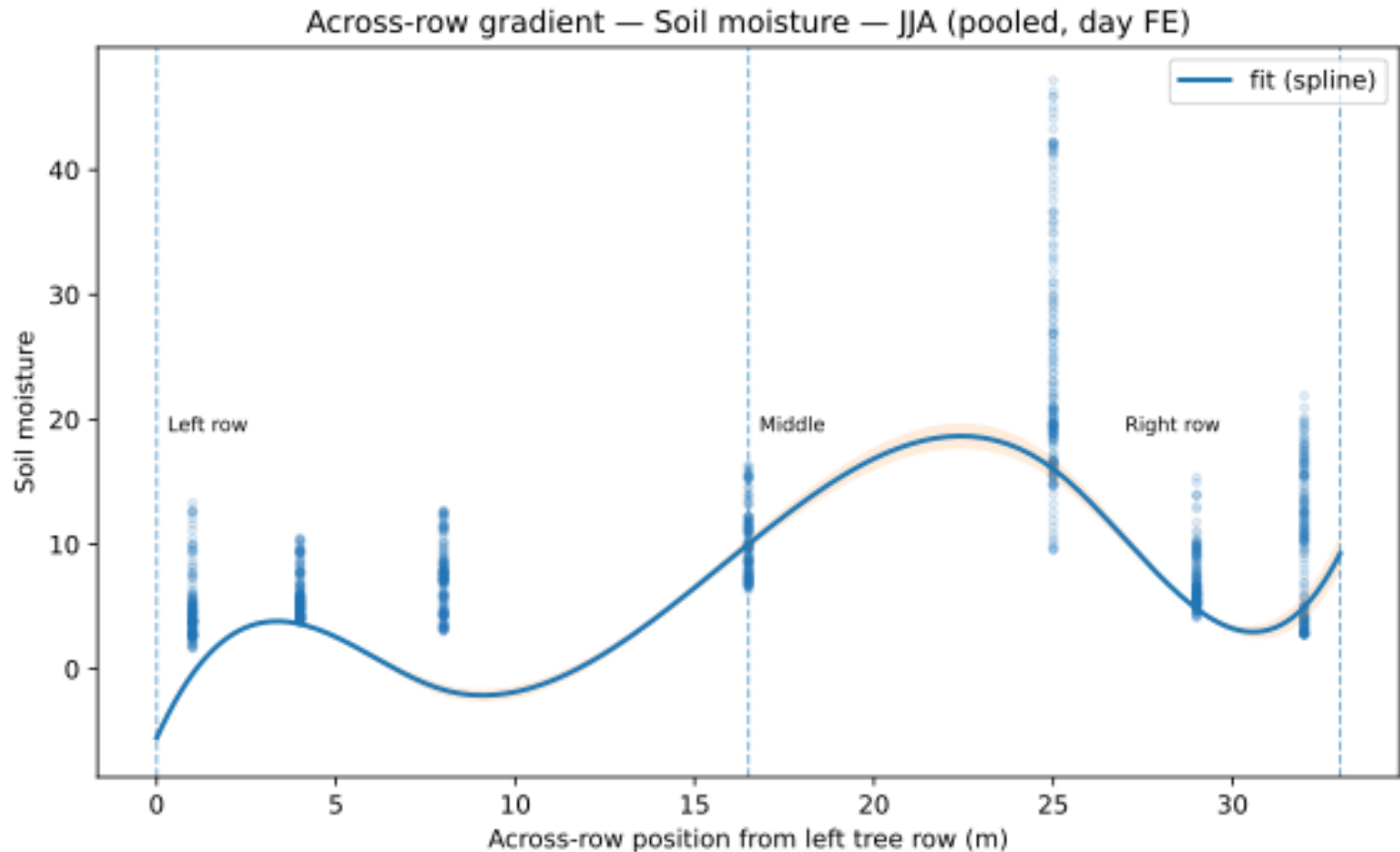


# Key Research Questions

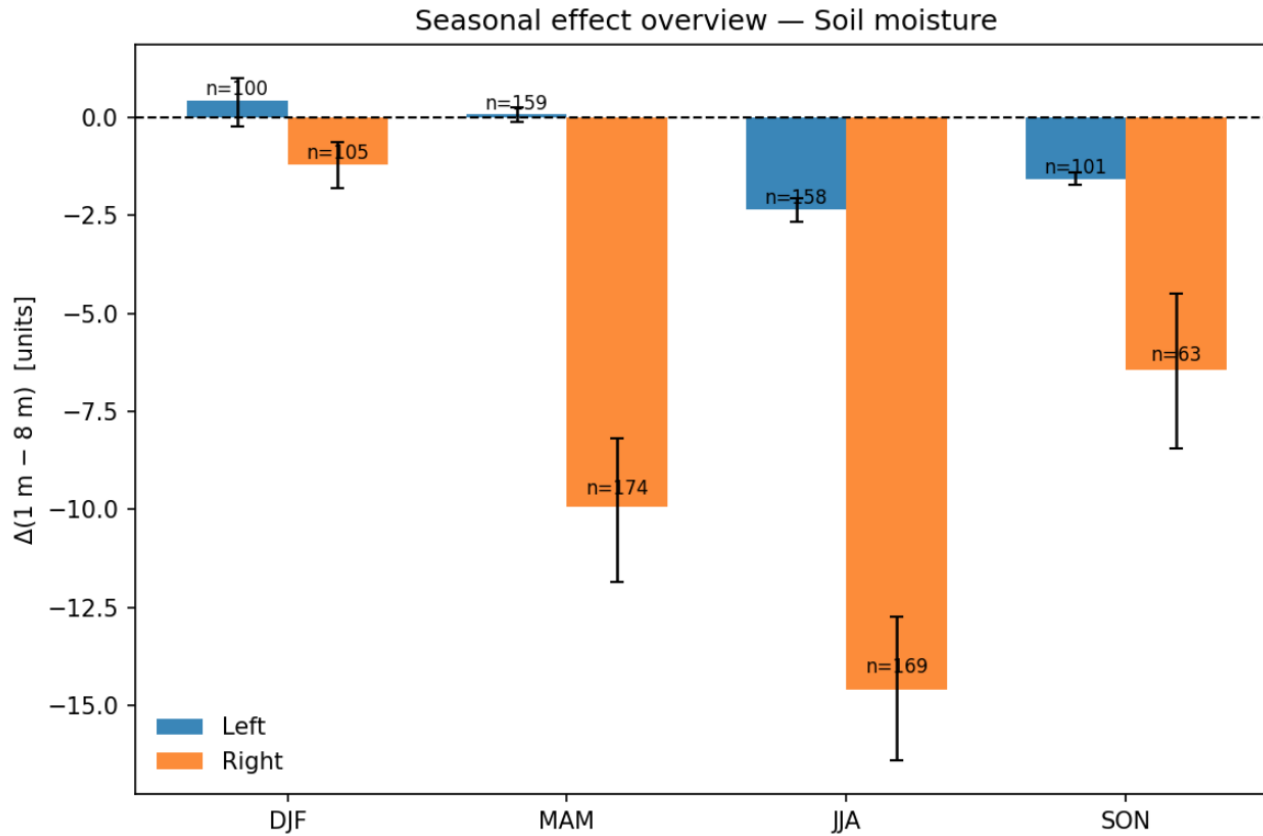
2. Are significant differences observed between sensor points placed at varying distances from the tree rows within the agroforestry system?



# Insight: Data can not be pooled

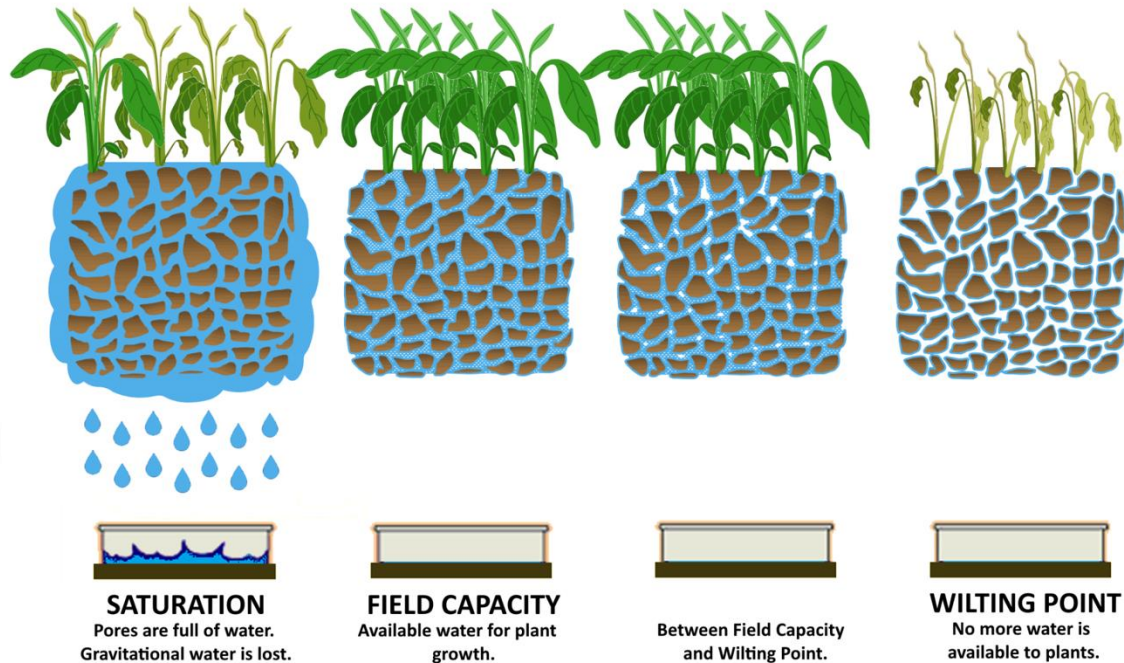


# Seasonal effects



# Key Research Questions

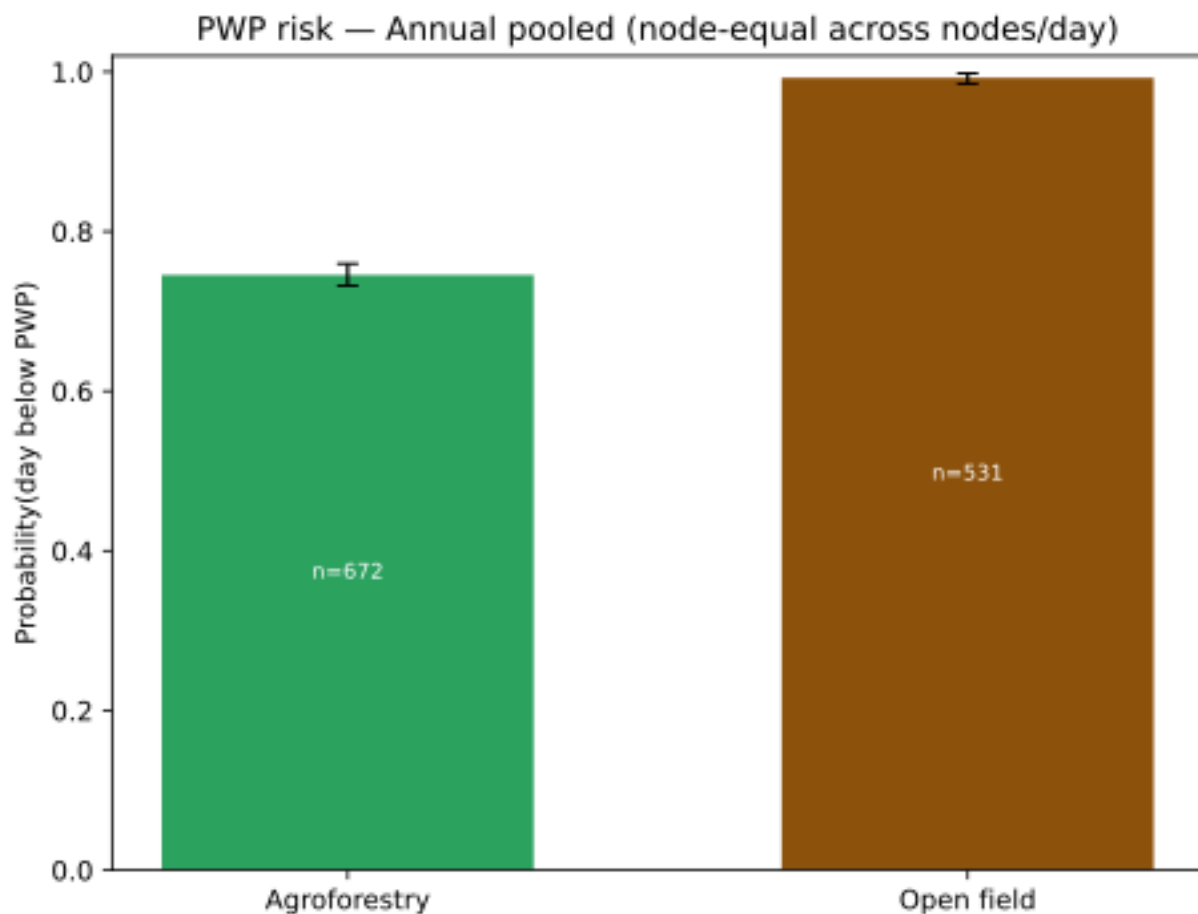
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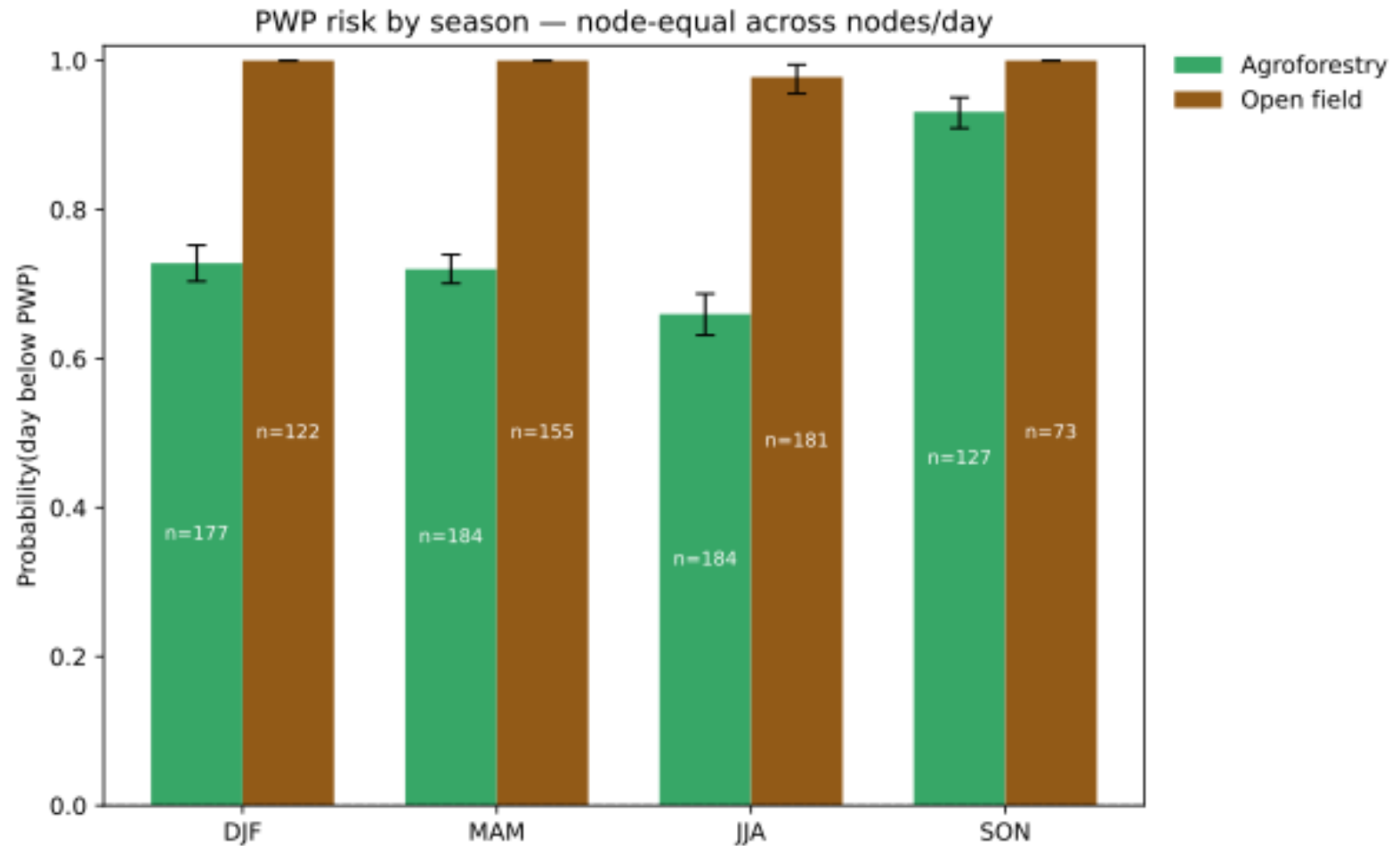
\* The Permanent Wilting Point is defined as the soil moisture content at which plants can no longer extract sufficient water to meet their physiological needs.

Pic: <https://connectedcrops.ca/the-ultimate-guide-to-soil-moisture/>

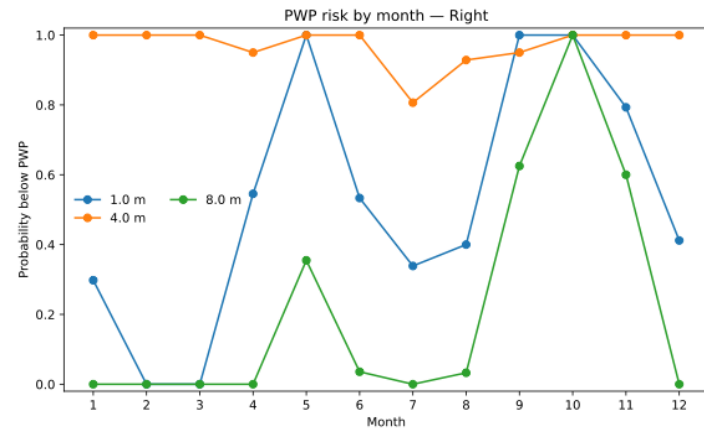
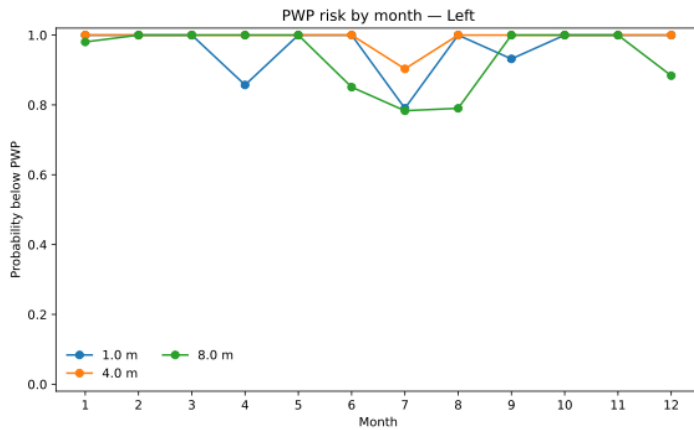
# Higher PWP risk in Open Field



# Seasonal effects

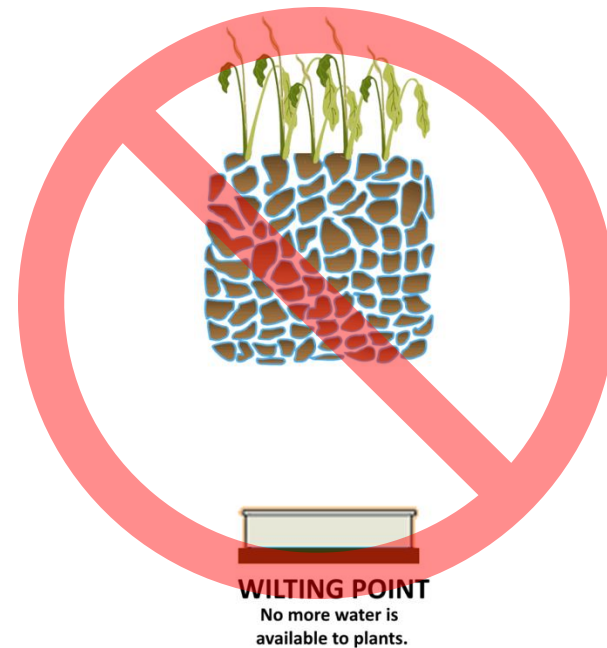
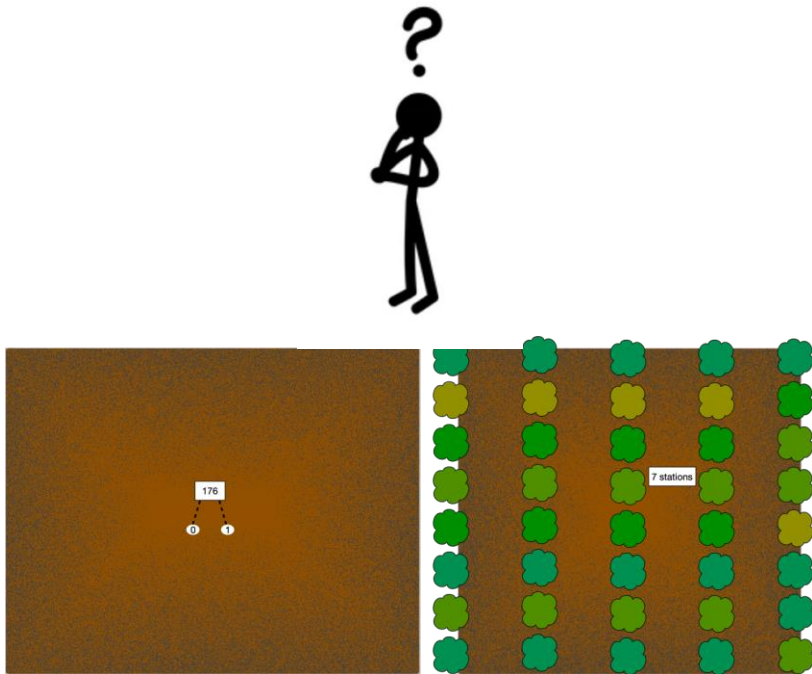


# Inside the gradient...



# Key Research Questions

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# Summary

- AF creates a **spatial gradient**: conditions change from the tree row toward the alley middle; **left vs right** often behave **asymmetrically**.
- When pooled by day and season, AF frequently shows **lower water-stress risk** than Open; the **gap varies by season** (largest in warm/dry periods).
- The **middle of the alley (~16.5 m)** can resemble **open-field** conditions; the **near-row bands (1–4 m)** are the most distinct.
- **Step contrasts (1→4, 4→8, 8→16.5 m)** and **within-day slopes** are stable, intuitive ways to quantify the gradient (better than simple lines).

# Operational insights

- **Placement:** moisture-sensitive crops (or young plantings) are better **near rows**; drought-tolerant crops can occupy **mid-alley**.
- **Monitoring:** a **site-day PWP risk** (share of nodes below threshold) is a simple, actionable KPI for irrigation & stress alerts.
- **Asymmetry-aware management:** treat **left and right** as potentially **different micro-zones** (sun/wind exposure).

