Effects of Forest Management Scenarios on Water Partitioning and Ecosystem Resilience: Insights from Long-Term Tracer-Aided Ecohydrological Modelling in a Drought-Sensitive Lowland Catchment

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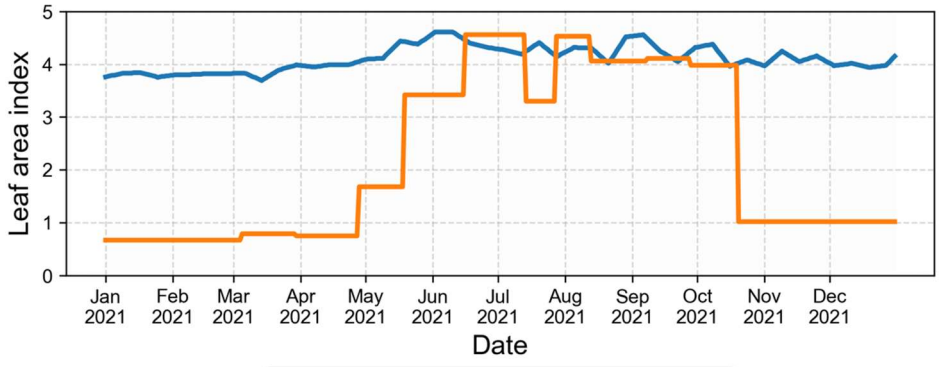
Broadleaf and Coniferous Forests in Winter



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Research Questions

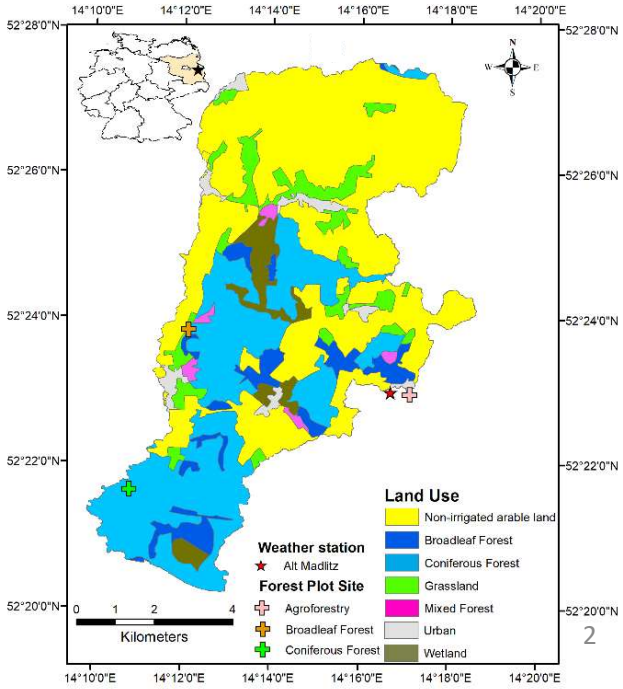
Issues and Motivation

- **Research Area:** Drought-sensitive lowland Demnitzer Millcreek catchment (DMC), 66 km^2, 550 mm P, 700 mm PET
- Increasing water scarcity and ecosystem stress
- Effects of forest management on water partitioning remain unclear
- **Goal:** Develop a framework to assess and visualize how land use changes impact water partitioning, supporting policymakers and land managers

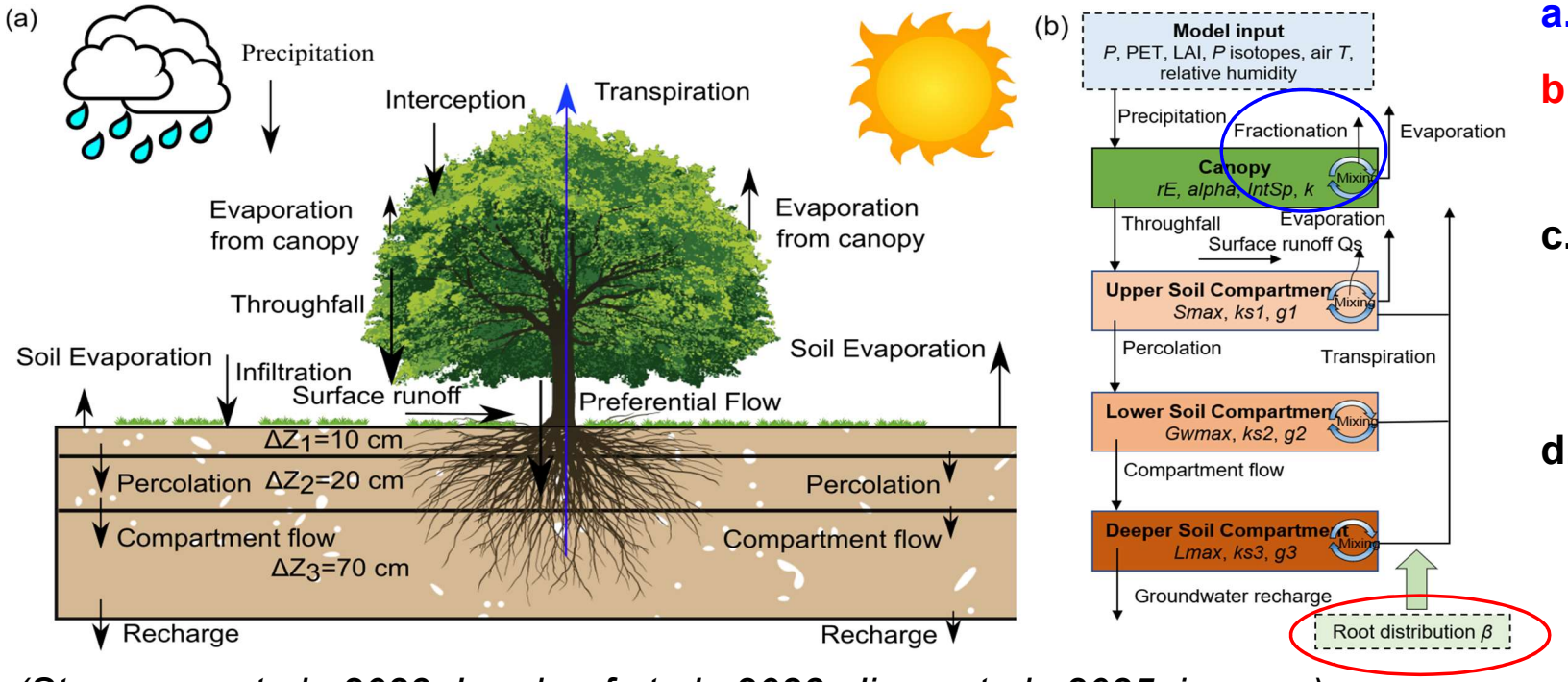
Research Questions

1. How does forest management affect the water partitioning?
2. How does this vary between forest type, density, root distribution across dry and wet years?
3. Which forest management strategies best improve water and resilience in drought-sensitive areas?

DMC and Land Use



Tracer-aided EcoPlot-iso Model & 3D Forest Scenarios



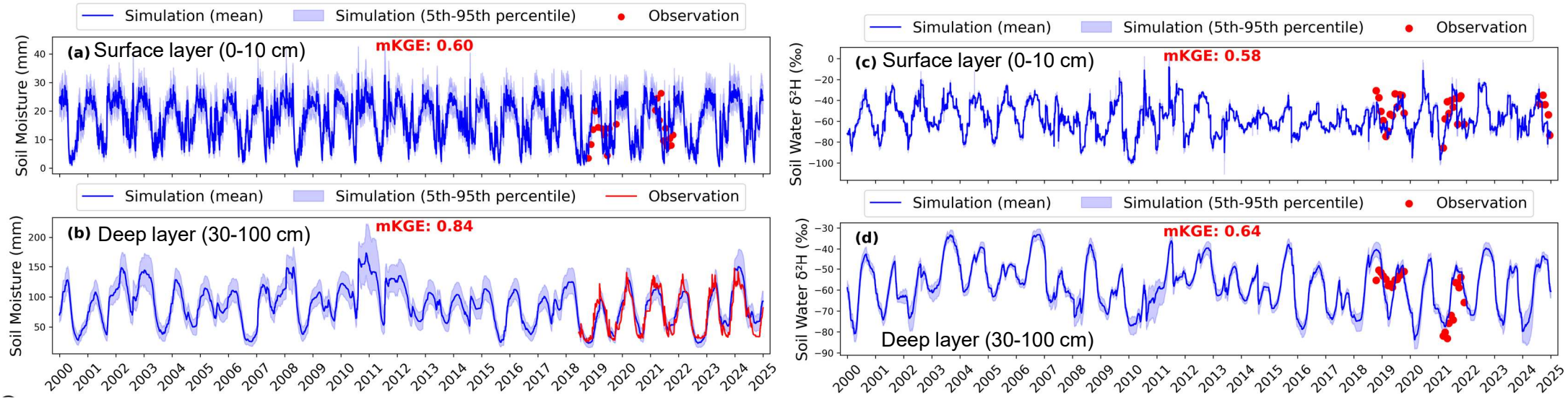
(Stevenson et al., 2023; Landgraf et al., 2023; Jiang et al., 2025, in prep.)

- **a. Tracer-aided Model**
- **b. Model Adaptation**
  - Root Distribution Function
- **c. Baseline simulation**
  - Broadleaf Forest Site
  - 2000-2024
- **d. Model Calibration**
  - Soil Moisture
  - Soil Water Isotope (δ^2H)
  - Monte Carlo Sampling
- **e. 3D Forest Scenarios**
  - Forest Type
  - Forest Density
  - Root Distribution

❑ Isotopes provide unique fingerprints of water paths, improving water flux and storage estimates. *(Soulsby et al., 2015; Tetzlaff et al., 2015)*

(Jiang et al., 2025, in prep.)

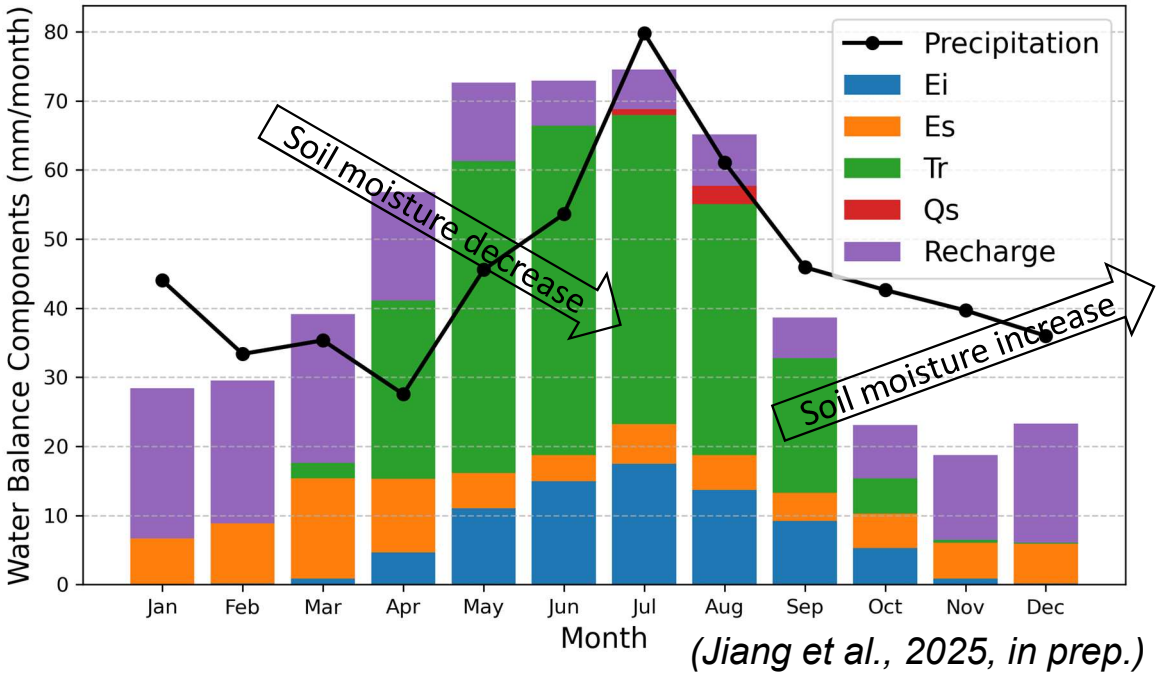
Baseline Simulations (2000-2024): Soil Moisture and Isotope Dynamics under Broadleaf Forest



(Jiang et al., 2025, in prep.)

- Soil water isotope sampling remain scarce due to its labor-intensive
- Model successfully reproduce 25-years of soil moisture & soil water isotope (δ^2H) dynamics
- EcoPlot-iso validated for exploring forest management impacts

Monthly Water Balance Components (2000–2024) under Broadleaf Forest



(Jiang et al., 2025, in prep.)

Ei: Canopy evaporation

Es: Soil evaporation

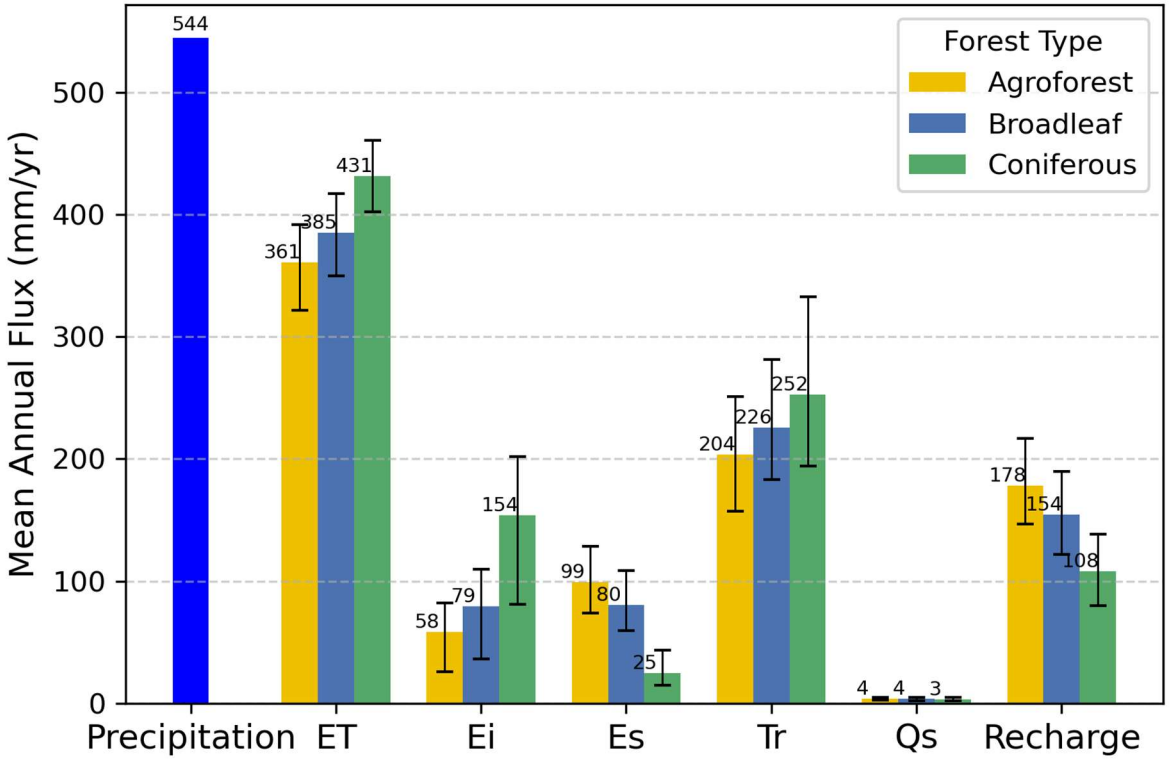
Tr: Transpiration

Qs: Surface runoff

Recharge: Groundwater recharge

- GW recharge dominates runoff
- Tr and Ei dominate in summer
- Qs is very rare in summer
- Soil moisture rises (Sep–Feb), declines (Mar–Jun)
- High interannual variability
- Provides a baseline for scenario evaluation

Annual Water Balance and Partitioning Across Forest Types



(Jiang et al., 2025, in prep.)

ET:

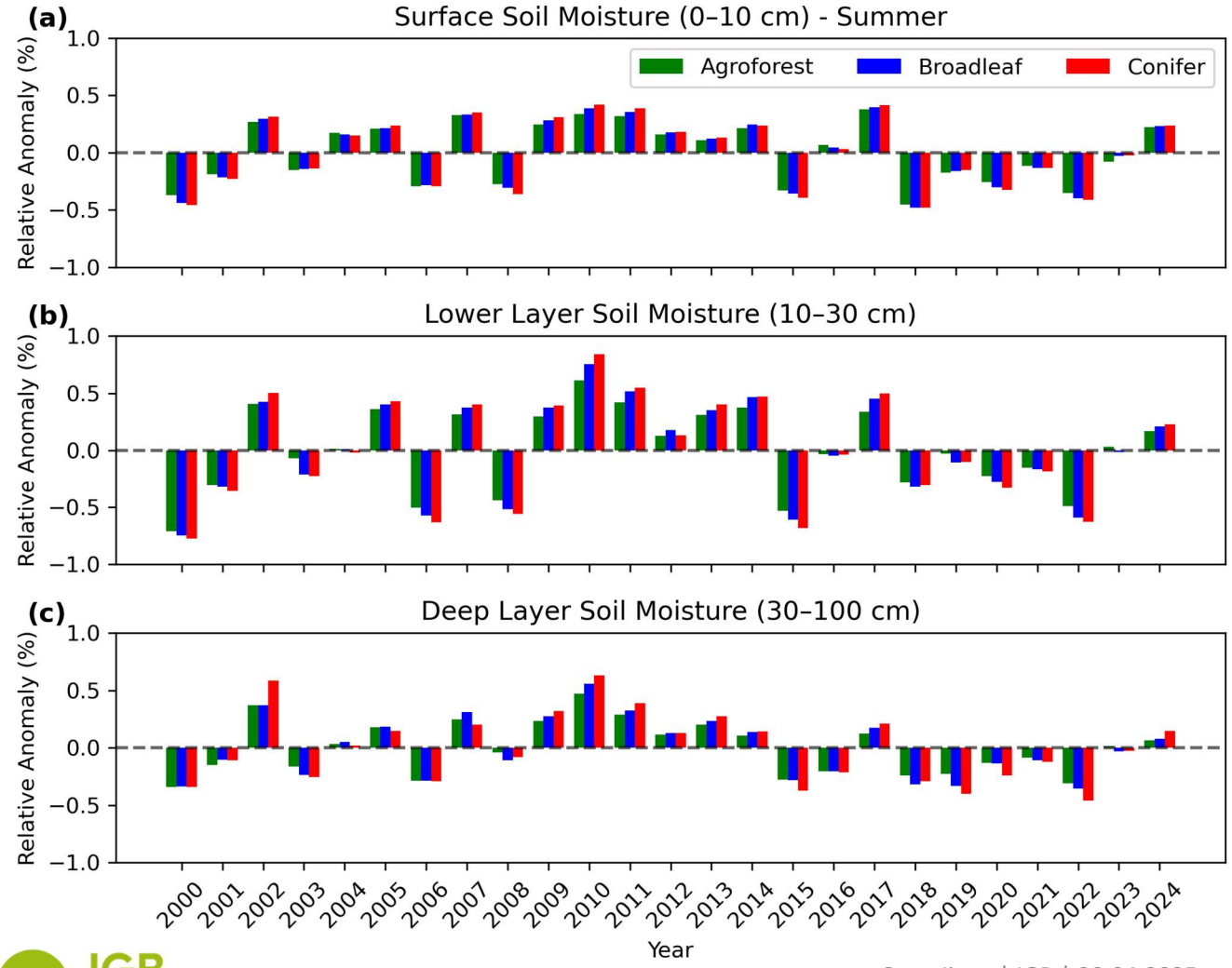
- Conifers: 431 mm/yr
- Broadleaf: 385 mm/yr → Conifers +8%*
- Agroforestry: 361 mm/yr → Conifers +13%

*Relative to P

GW Recharge:

- Conifers: 108 mm/yr
- Broadleaf: 154 mm/yr → Conifers -8%
- Agroforestry: 178 mm/yr → Conifers -13%

Soil Water Moisture Anomalies Across Forest Types



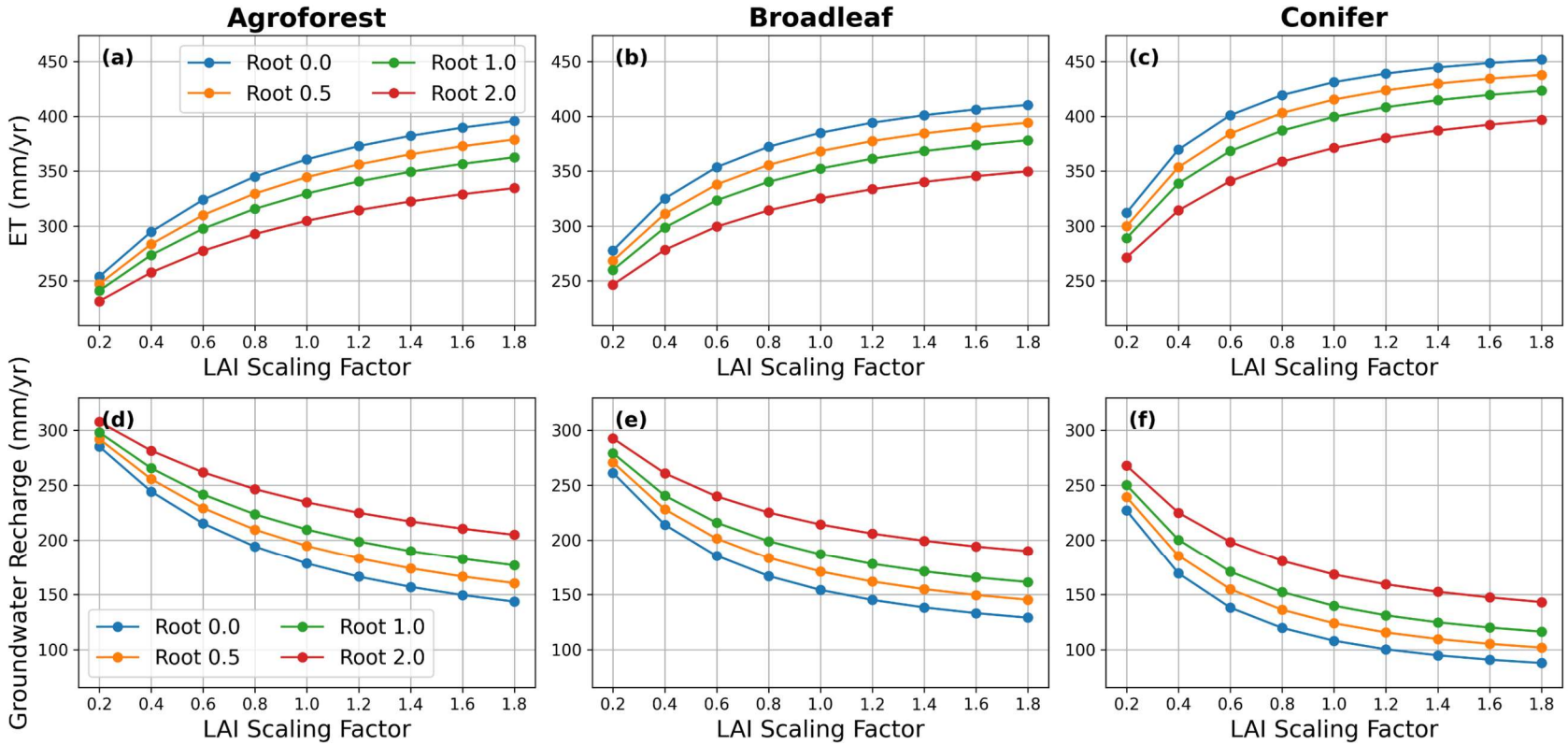
- Intermediate soil layer (10–30 cm) is most drought-sensitive (anomalies up to 0.8)
- Conifers: intensify drought effects (strongest anomalies)
- Agroforests: buffer drought impacts (most stable soil moisture)

(Jiang et al., 2025, in prep.)

3D Forest Management Scenarios and Impacts on ET and GW Recharge

Forest Scenarios:

- Forest Type
- Forest Density (LAI scaling factor)
- Root Distribution (shape parameter β)



- Trade-offs between ET and groundwater recharge
- Visualization tools for sustainable water and land management

(Jiang et al., 2025, in prep.)

Take Home Messages

- EcoPlot-iso simulates water storage and fluxes well under baseline conditions
- Clear trade-offs between ET and groundwater recharge, but depending on forest scenarios
  - Conifers: Highest ET (430 mm/yr), +13% vs agroforestry, +8% vs broadleaf, strongest drought effects
  - Agroforestry: Lowest ET, highest recharge, most stable soil moisture
  - Broadleaf: Moderate ET and recharge, intermediate drought response
- Provide a visual tool to guide forest planning and resilient land use

Still from our *Landscape Ecohydrology* Group at EGU (on isotopes):

- D. Tetzlaff: Wed, 08:35-08:45, 2.44
- H. Zheng: Wed, 08:45-08:55, 2.44

Thank you for your attention! Any questions?