

Emulating SWAT+ for Hydrological and Water Quality Prediction: A Multi-Stage Random Forest Approach

Nada Jumaa¹, Javier Osorio Leyton^{1,2}, Amy Hansen³, and Natalja Čerkasova¹

¹ Blackland Research & Extension Center, Texas A&M AgriLife Research, Temple, TX 76502, USA.

² Department of Rangeland, Wildlife, and Fisheries Management, Texas A&M University, College Station, TX 77843, USA.

³ Civil, Environmental, and Architectural Engineering, University of Kansas, Lawrence, KS 66045, USA.

**2025 SWAT Conference
20-24 October | Colorado, USA.**



I. Research Question And Motivation:

Can the ML emulate the SWAT+ model?

- ✓ WB, WQ variables
- ✓ Scalable (Field: HRU-Regional: UMRB)
- ✓ Large Agri-conservation practices Basin

Why?



- timely and accurate decision-making
- Effective watershed management modeling
 - Data (availability/quality)
 - Water process ~ watershed characteristics
 - Large heterogeneous agricultural basin.



➤ **Efficient modeling framework**

- ✓ **SWAT+:**
 - large heterogeneous landscapes.
- ✓ **data-driven models:**
 - physical relationships.
 - generalization across regions.

⚙️ **Problems?**

➤ **powerful tool:**

Physics-guided Random Forest Regression (RFR) model emulates SWAT+ outputs.

- ✓ Scalability.
- ✓ Transferability.



Benefits?



Issue

Do current modeling frameworks have the capacity to evaluate effective watershed management across large and heterogeneous basins?

So What?



➤ **Evaluating conservation practices:**

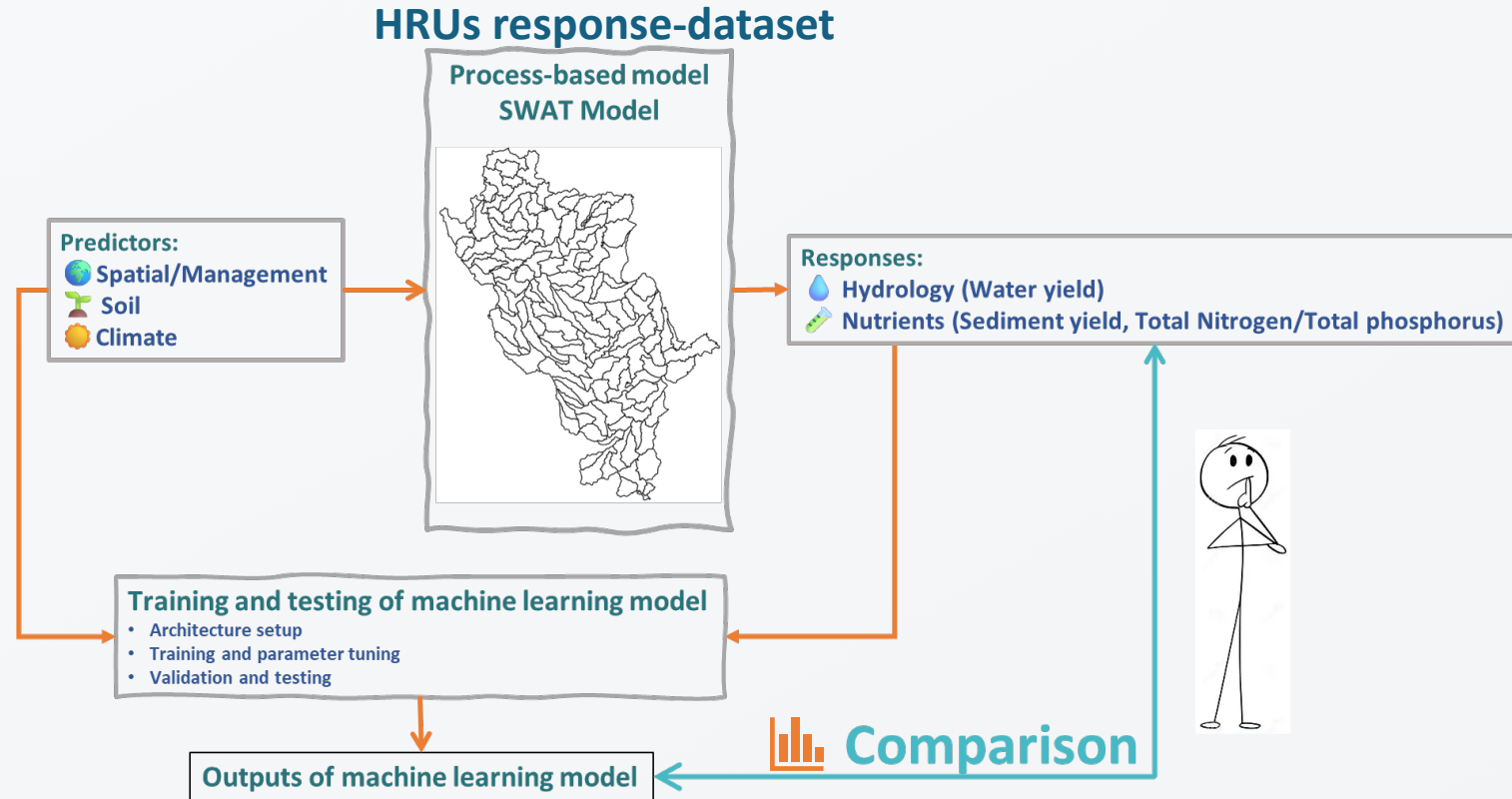
- ✓ Hydrologic and water quality hotspots.
- ✓ Supporting management decisions.



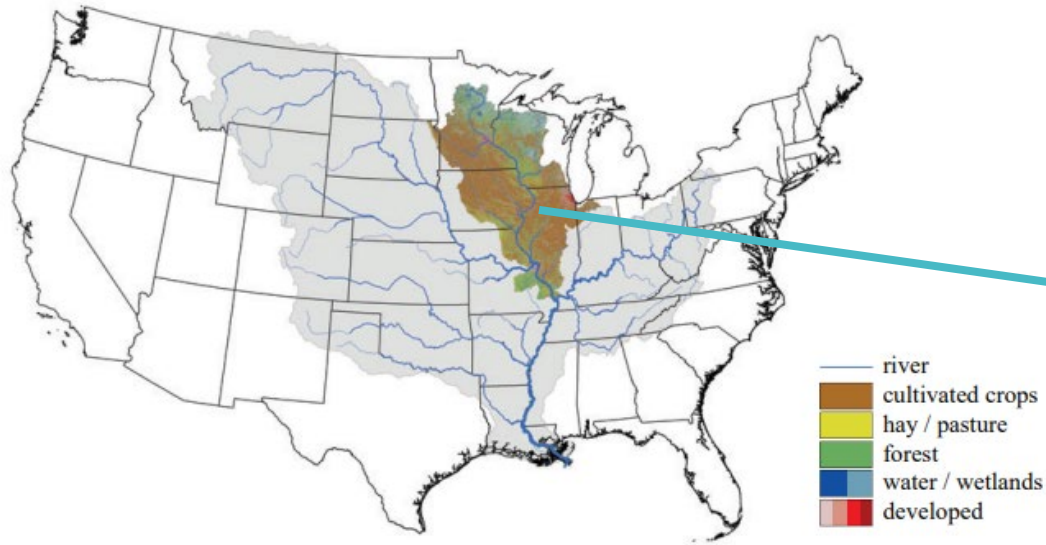
Solutions?

A **multi-stage physics-guided RFR framework** to replicate SWAT+ outputs and spatial variability efficiently.

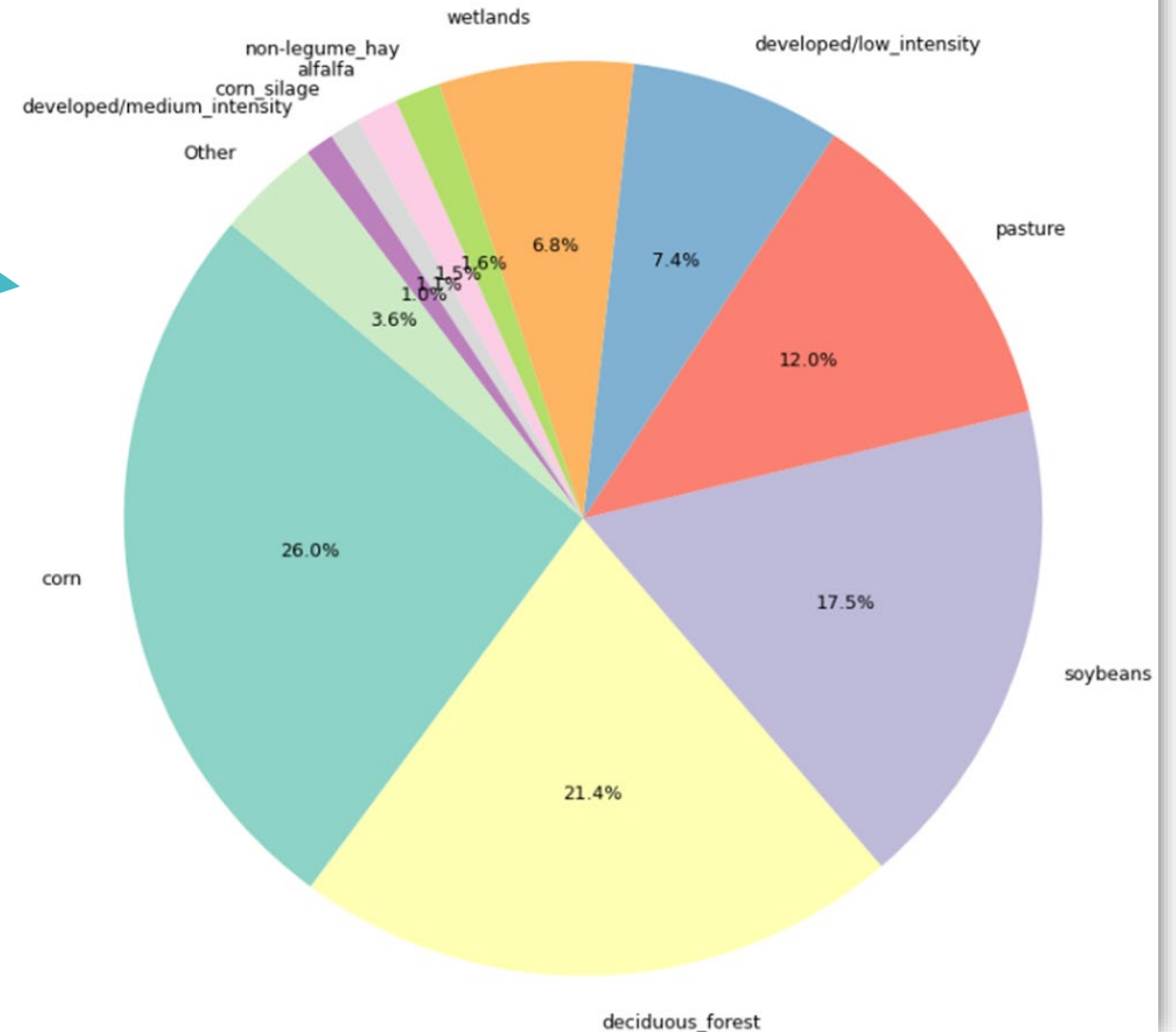
II. Research Goals & Approach:



III. Study area-Dataset:



Top 10 LANDUSE Classes by AREA in UMRB



National Agroecosystem Model subset: Upper Mississippi River Basin HUC8 Scale SWAT+ model

White, Michael (Contact person)¹ ; Čerčasova, Natalja (Researcher)² ; Arnold, Jeffrey G. (Researcher)¹ ; Gao, Jungang (Researcher)² ; Allen, Peter M. (Researcher)² ; Gambone, Marilyn (Researcher)¹ ; Rath, Sagarika (Researcher)² ;

Show affiliations

This dataset is a subset of the National Agroecosystem Model (NAM) (see doi: 10.1111/1752-1688.13056 for details) for the Upper Mississippi River Basin (UMRB) using the Soil and Water Assessment Tool (SWAT+). There are 132 folders in the dataset, each represents a standalone SWAT+ model.

- The folders contain all the necessary input data and files to run the SWAT+ model.
- Each folder includes a SWAT+ executable, named XXXXXXXX_swat.exe used to run the model and to get the desired output. The XXXXXXXX is the corresponding HUC8 number.
- Each folder contains a XXXXXXXX_Combo.png image, which shows the performance of the corresponding HUC8 model, where XXXXXXXX is the HUC8 number. The model output is compared to the USGS water yield estimates from Reitz et al. 2017 (doi: 10.1111/1752-1688.12546), and the SPARROW model.

This subset of the NAM was soft-calibrated for water yield and corn/soybean yields. Some hard-calibrated was performed on a local stream reach level Using Dynamically Dimensioned Search Algorithm (citation will be updated once available).

Files <https://doi.org/10.5281/zenodo.12750127>

Files (5.7 GB)		
Name	Size	Download all
NAM_UMRB_SWAT+_7z		
This site uses cookies. Find out more on how we use cookies		

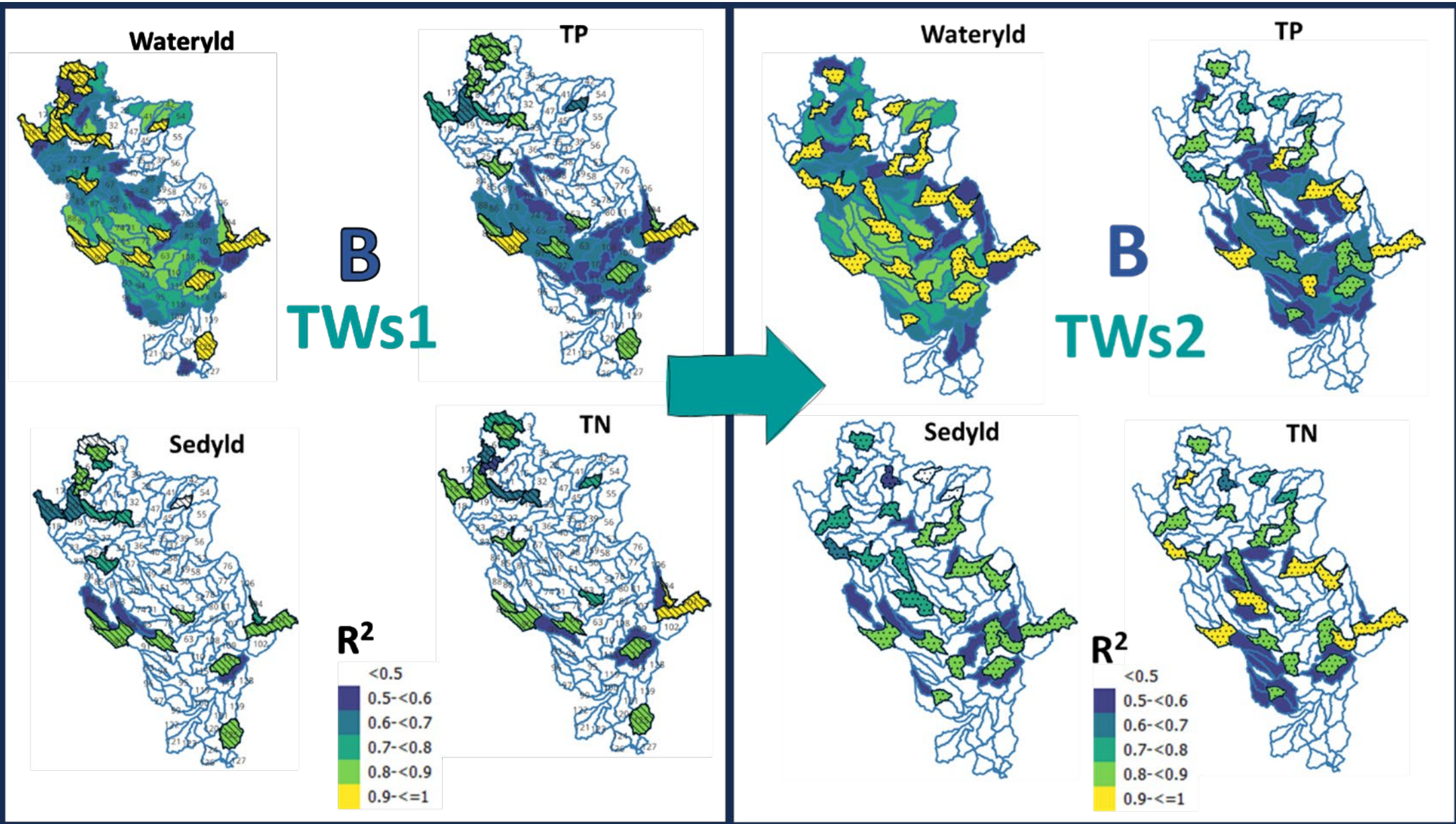
III. Method:

Single + Generalizable Model for the Entire UMRB

**Representative Training Sample
“Sub-watersheds”**

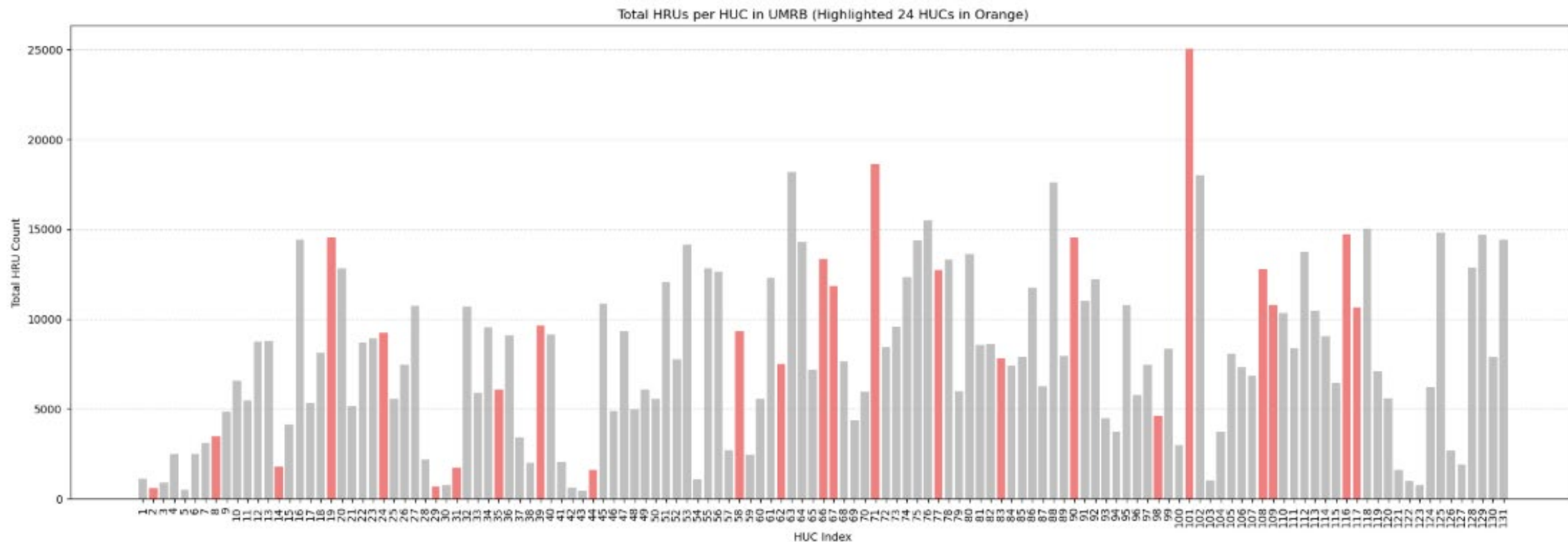


III. Results:



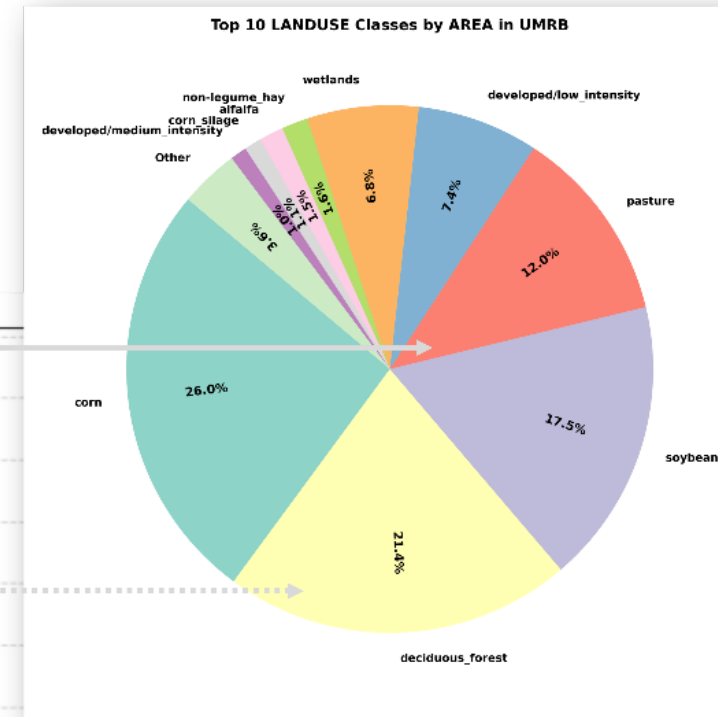
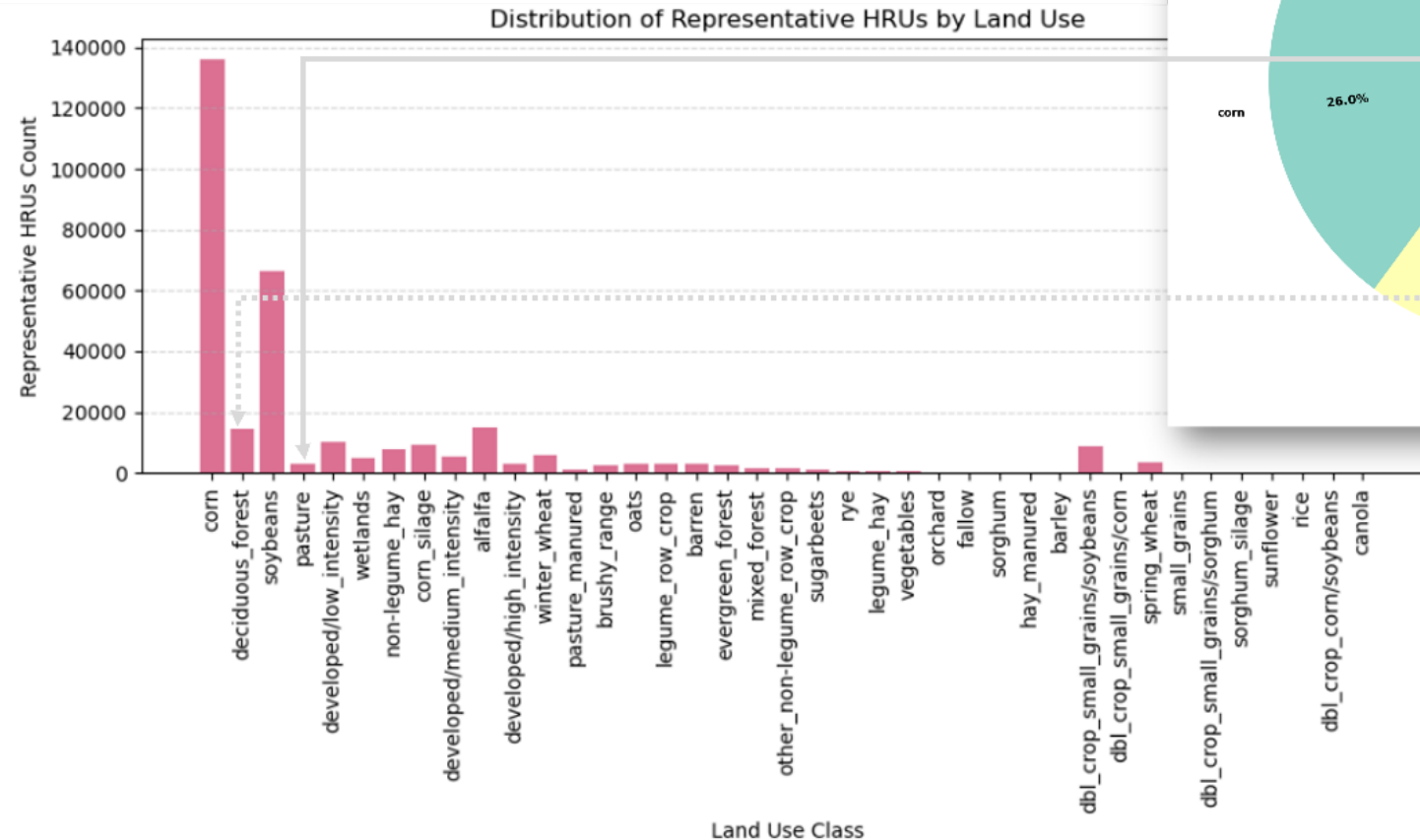
III. Analysis:

The distribution of HRUs in the representative 24-HUC8

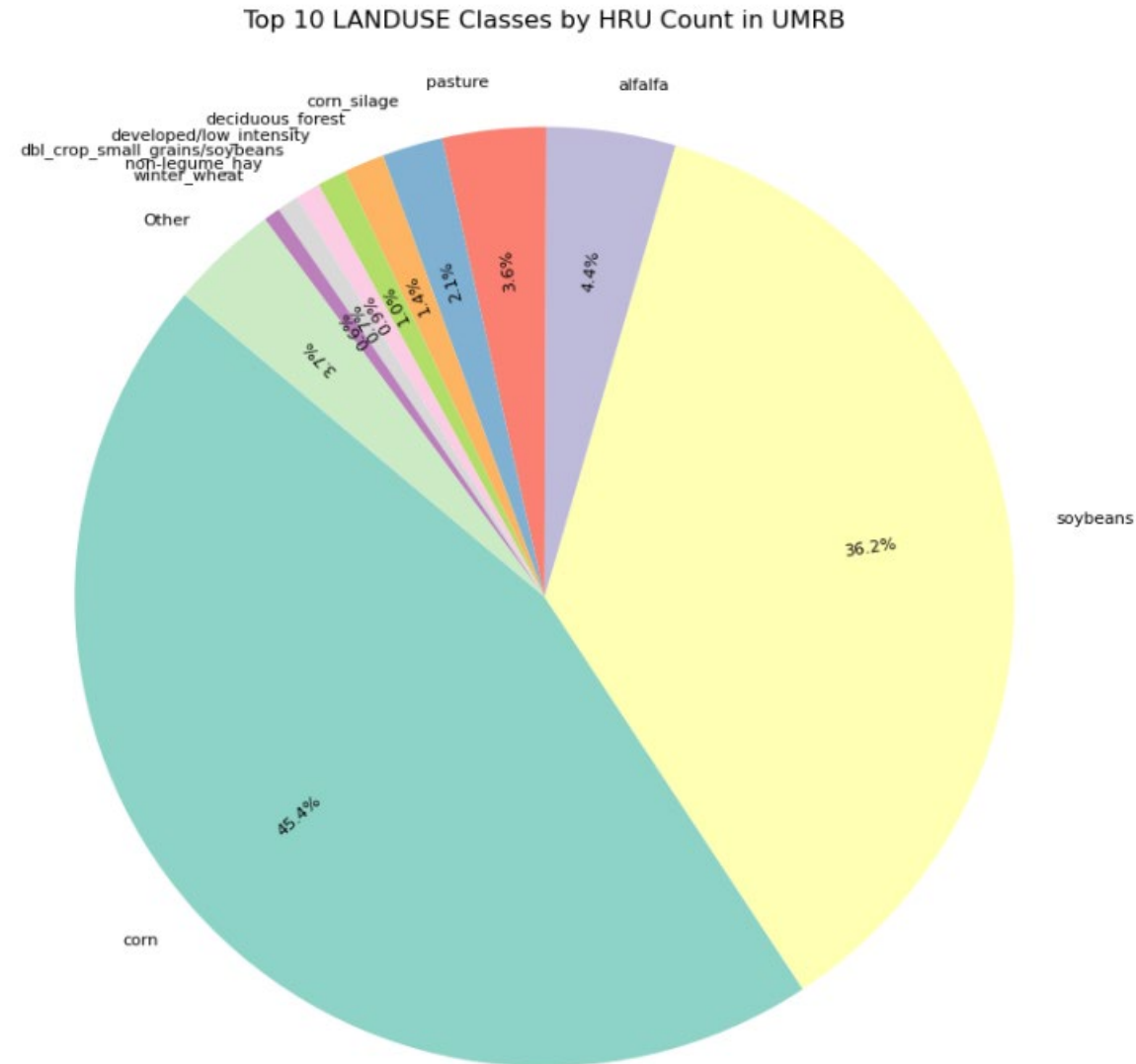


III. Analysis :

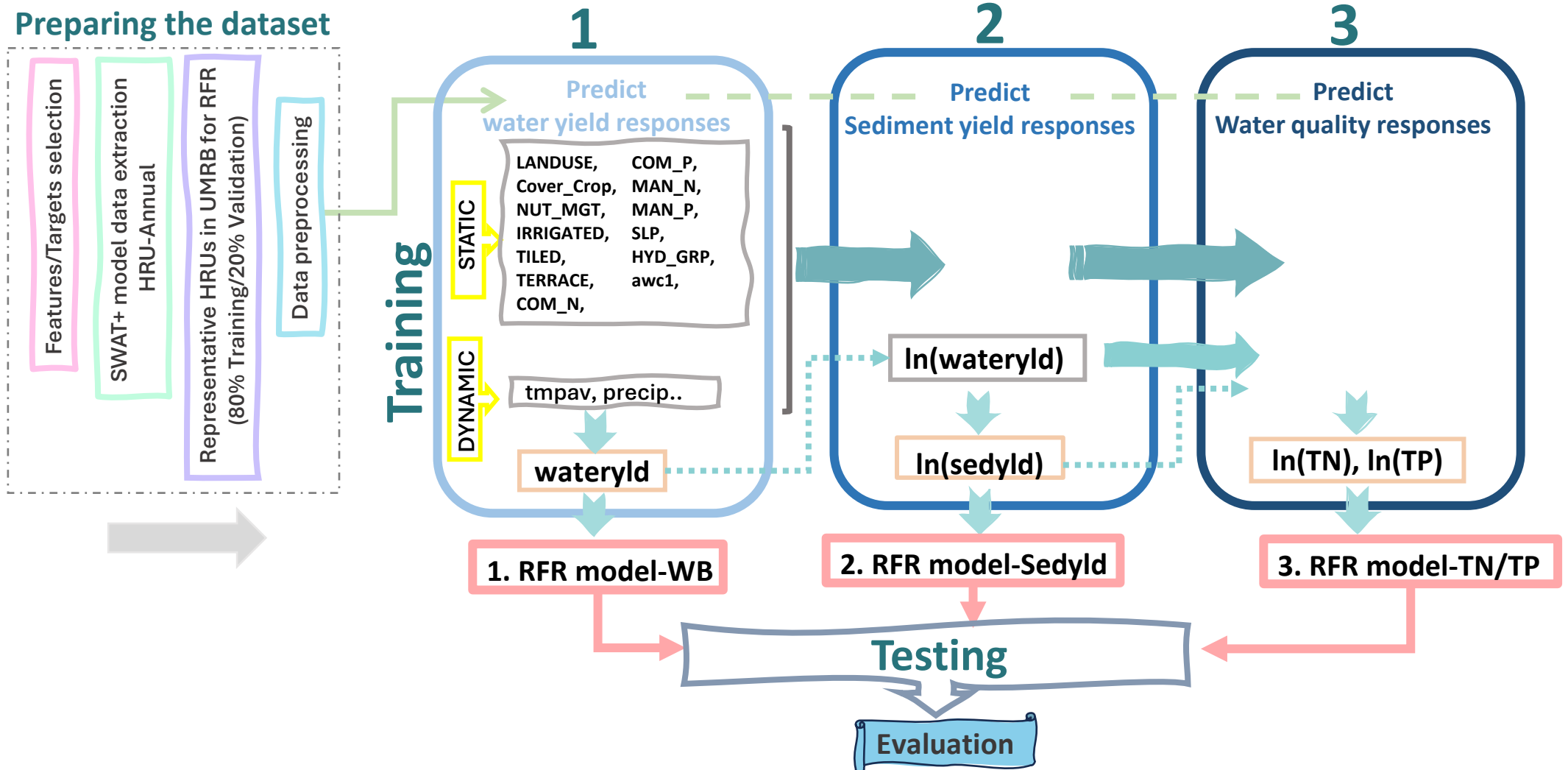
The distribution of area and HRUs in land use classes.



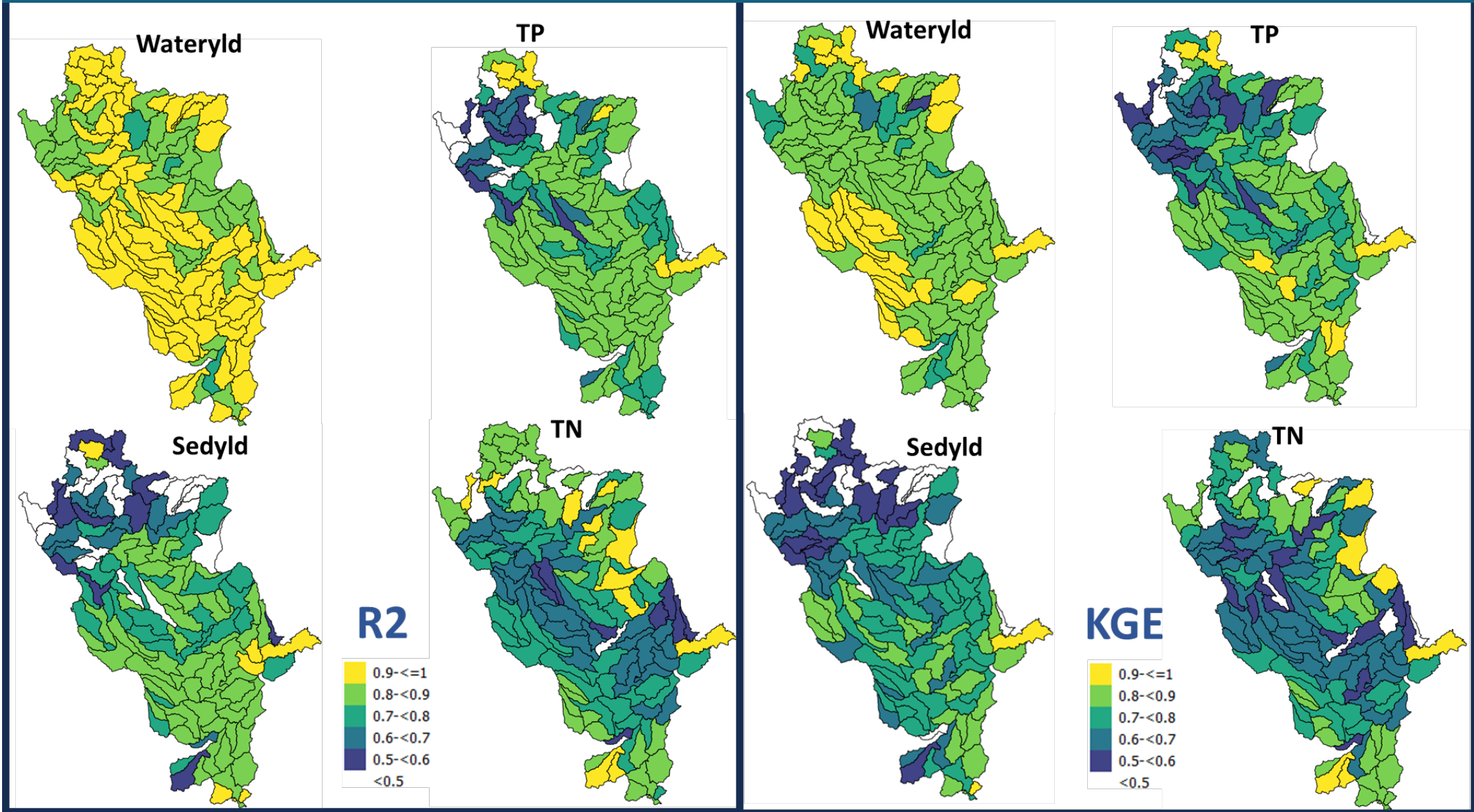
III. METHOD:



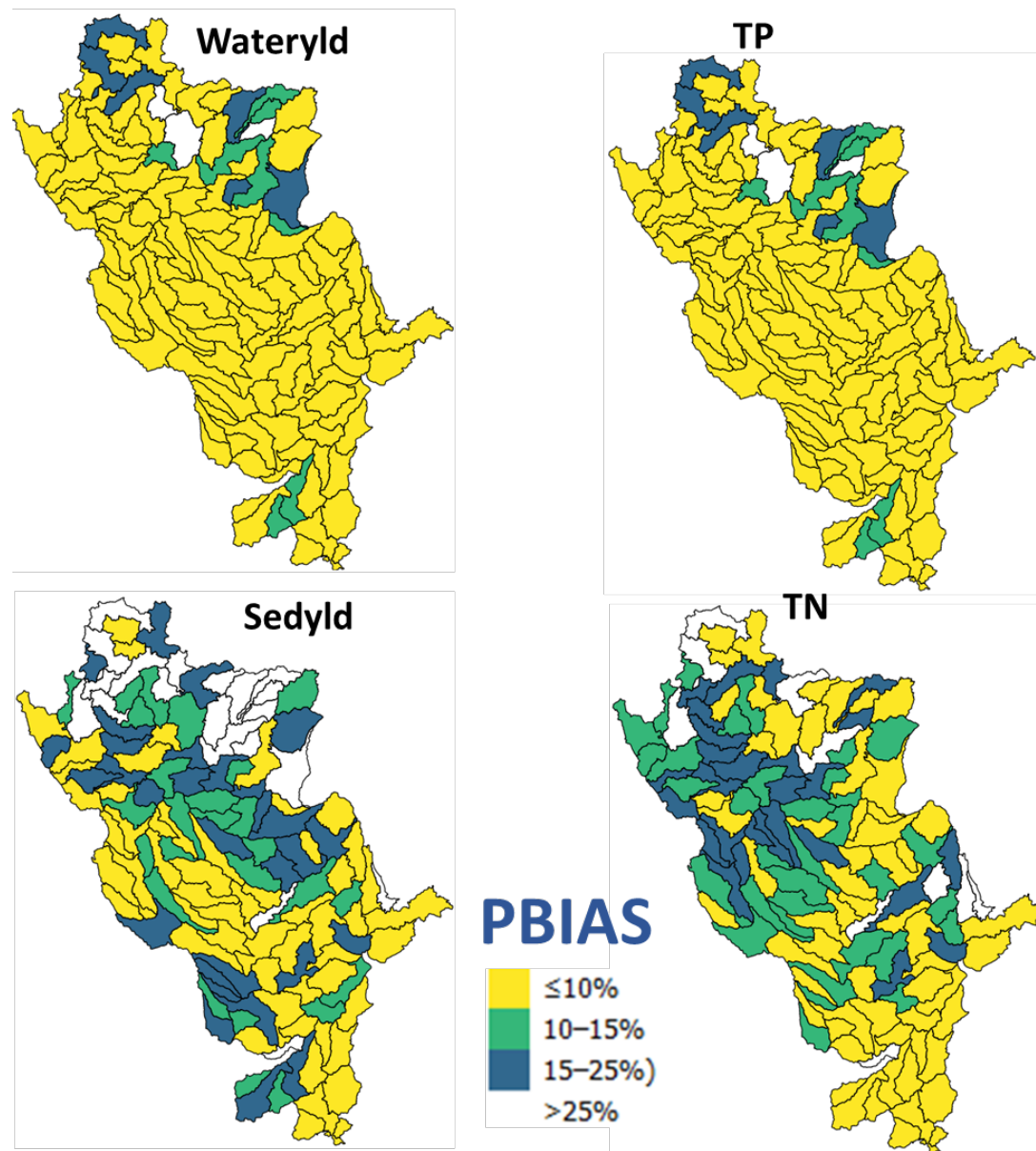
III. METHOD: A Multi-Stage Random Forest Approach



V. RESULTS:



V. RESULTS:



III. Conclusion:

- ✓ **Surrogate**
- ✓ **Scalable**
- ✓ **Transferable**
- ✓ **Large heterogeneous agricultural basin**
- ✓ **Real-time watershed management decisions**



THANK YOU

