

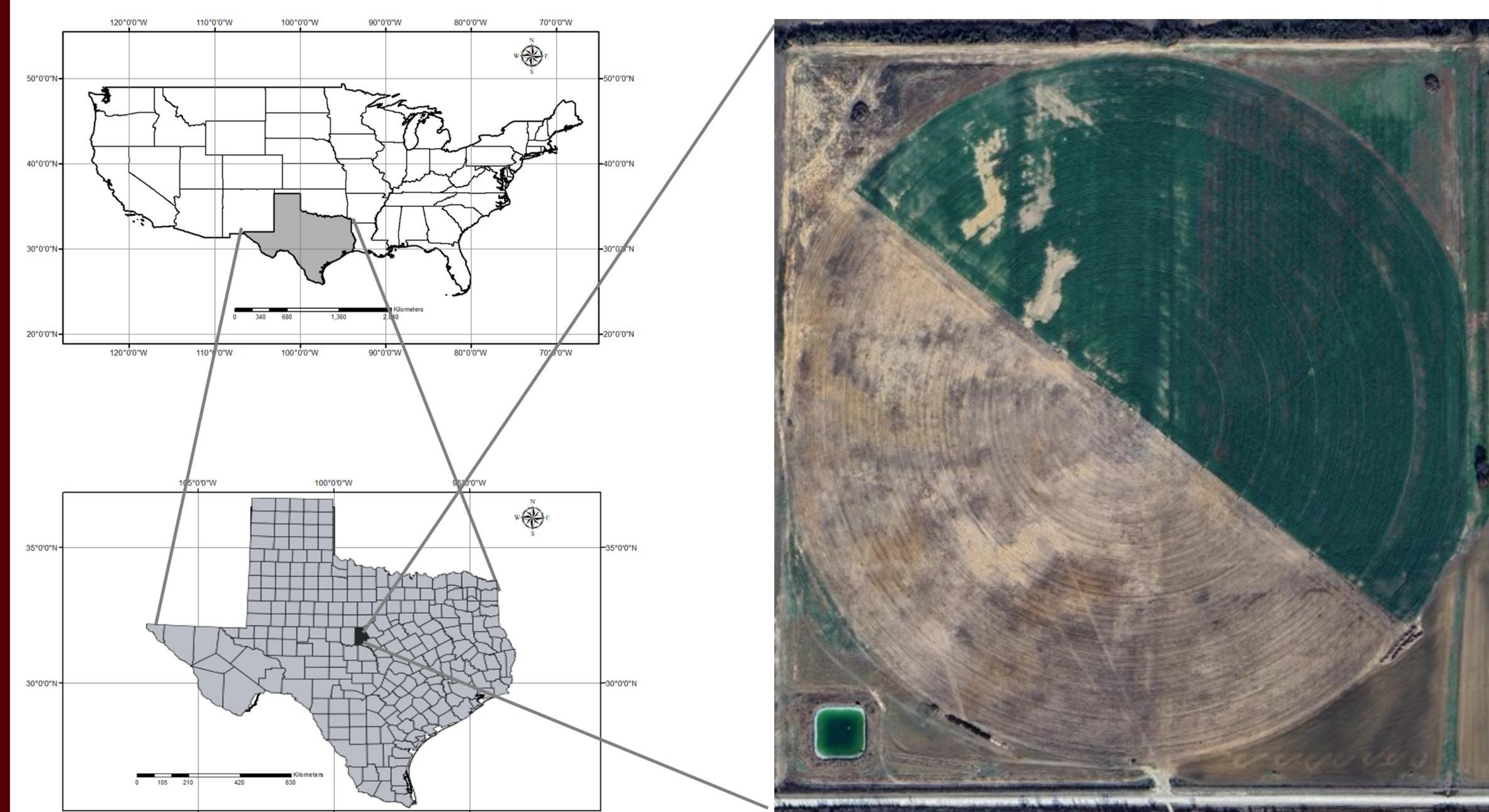
Background

- **Accurate biomass estimation** is essential for optimizing irrigation scheduling, harvest timing, and forage supply in alfalfa production.
- **Satellite imagery** (e.g., PlanetScope) provides high spatio-temporal resolution, but models require **ground-truth data for calibration**.
- Biomass sampling is **labor-intensive and logistically challenging**, especially for large producer fields and perennial crops requiring **6–7 samplings per year across multi-year cycles**.
- Previous studies have used **UAV-based imagery with ML/DL models**, but UAVs are limited by **low temporal resolution and logistical constraints**.
- **Satellite-based approaches**, combined with geospatial machine learning, can overcome these challenges by integrating **multitemporal imagery with ground biomass measurements**.
- Understanding the **growth cycle dynamics** (dips after harvest, regrowth plateaus) is critical for **real-time harvest and irrigation decision-making**.

Objective

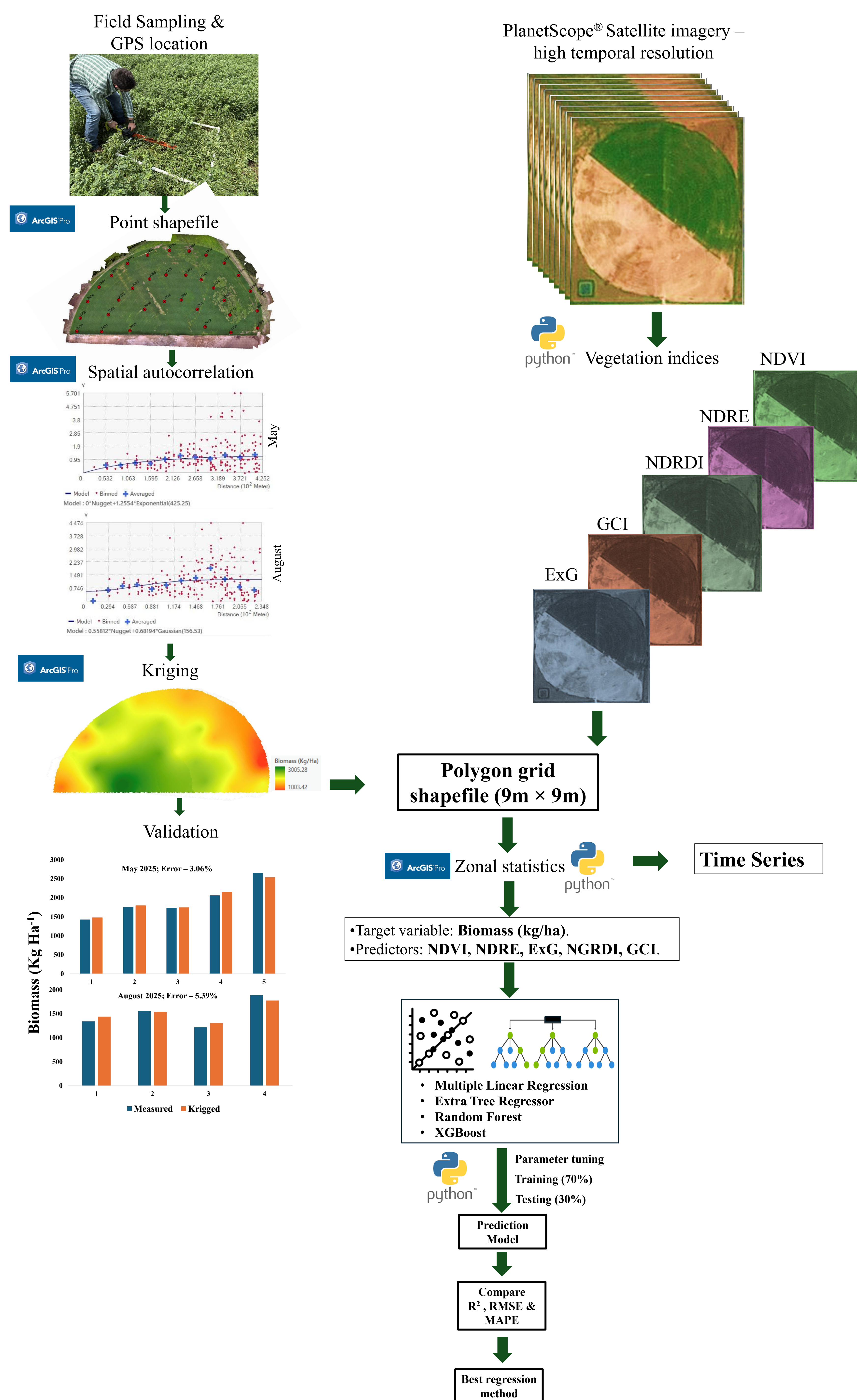
- **Develop and validate geospatial machine learning models** that integrate multitemporal PlanetScope satellite data and ground-truth biomass sampling to accurately estimate alfalfa biomass at field scale.

Location of study

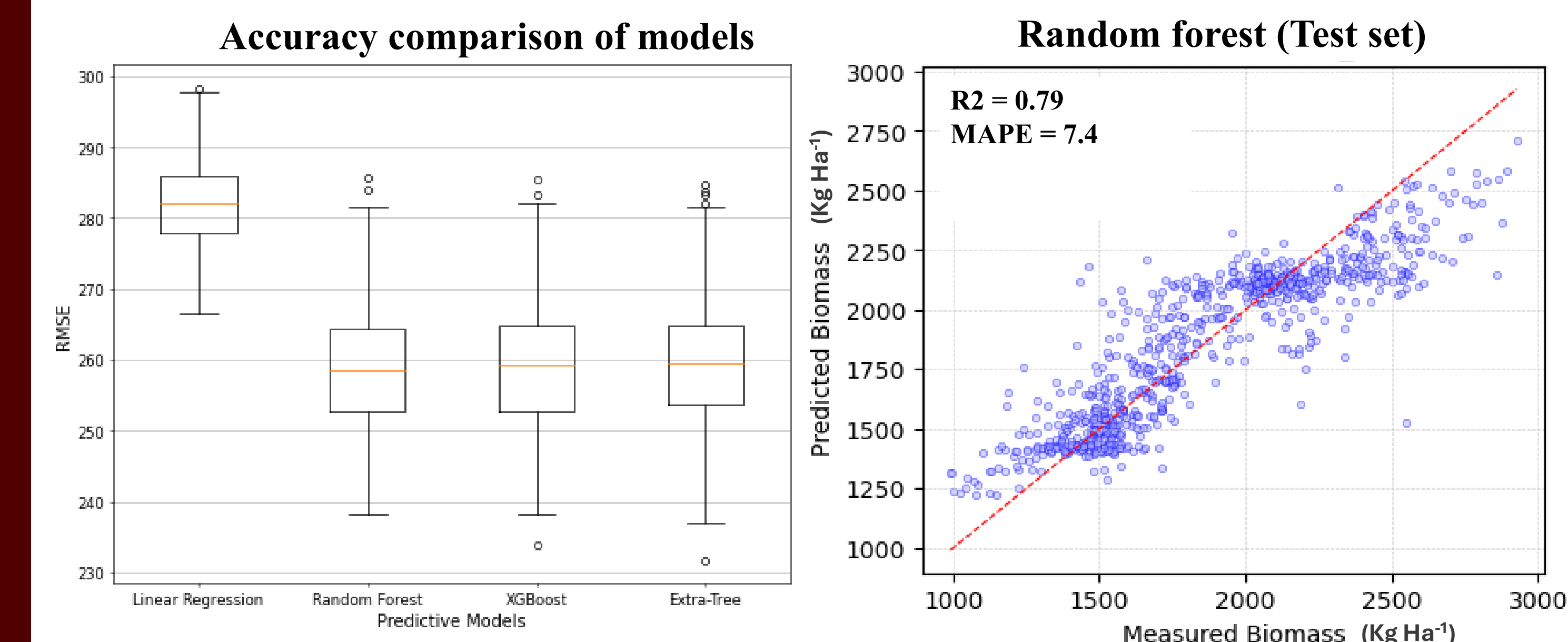


May, TX

Methodology

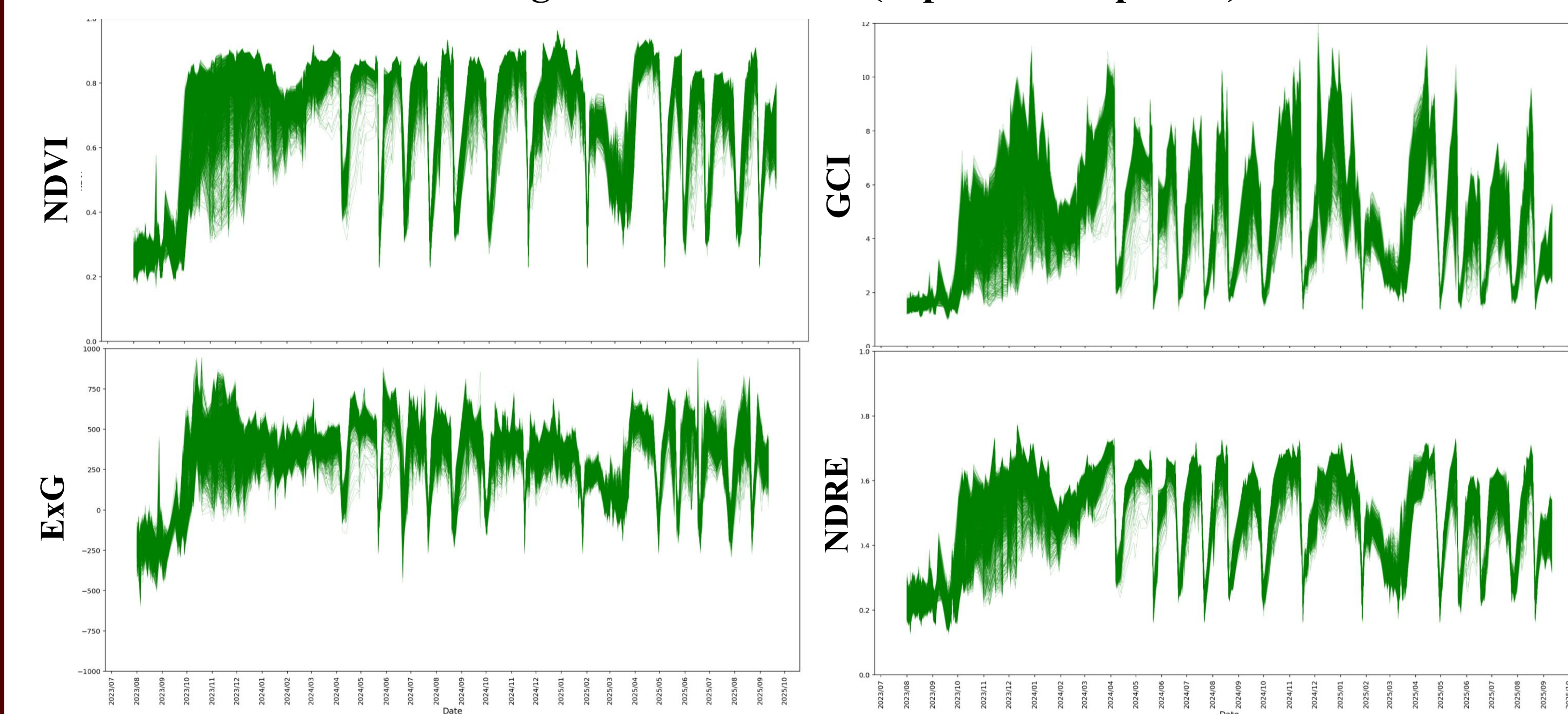


Results



- Random Forest (RF) achieved the best prediction accuracy ($R^2 = 0.79$, MAPE = 7.4%) compared to MLR, XGBoost, and Extra Trees.

Vegetation time series (Sep 2023 – Sep 2025)



Conclusions

- Multitemporal PlanetScope imagery combined with machine learning provides reliable estimates of alfalfa biomass at field scale.
- Satellite-based indices effectively track alfalfa growth and harvest cycles, offering practical alternatives to intensive biomass sampling.
- RF models outperformed other tested regressors, demonstrating robustness in predicting biomass from vegetation indices.
- Geospatial modeling enables site-specific monitoring that supports data-driven decision-making in alfalfa management.

Future Work

- Extend modeling to forage quality parameters (ADF, NDF, fiber, crude protein, lignin, digestibility).
- Develop near-real-time biomass prediction pipelines to support operational harvest and irrigation scheduling.
- Scale methodology to multiple fields and growing seasons for broader validation and deployment.

Acknowledgment

- USDA-NIFA
- Yme Bosma (alfalfa producer, May TX)