Building Field-Based Ecophysiological Genome-to-Phenome Prediction

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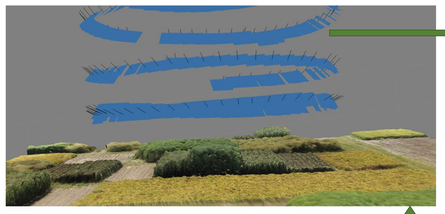
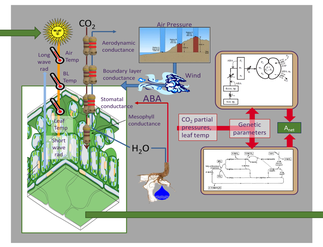
Situation: Feeding the estimated global population of 9 billion persons by 2050 will require a doubling of the food supply. However, the annual yield rates of gain for major grain crops is only one-quarter to one half of that which is necessary to reach this target. Remedying this deficit necessitates drastic improvements in the ability to predict crop field behavior based on its genetics and the growth environment. This is critical both for breeding programs and for efficient management in farmers' fields after new varieties are released. This project aims to increase the capacity of Kansas and Oklahoma to conduct research on quantitative prediction methodologies using wheat as a model crop plant.

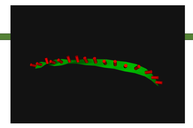


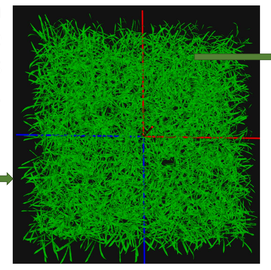
Flying UAVs in unconventional trajectories can yield better data on previously difficult to obtain variables. Novel spiral patterns are being studied as a way to collect canopy light interception as well as leaf temperature.



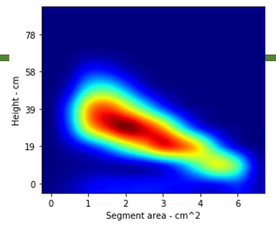
Interestingly, coercing two common photosynthetic submodels to give the same value solves a large set of biophysical eq'ns.

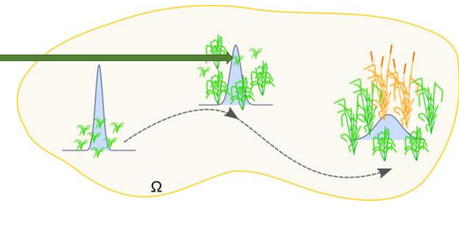
Extant ***Functional Structural Models*** (FSMs) combine ecophysiology with highly realistic morphology to produce virtual plants at computational costs not tenable in the current context. This project uses a different approach.



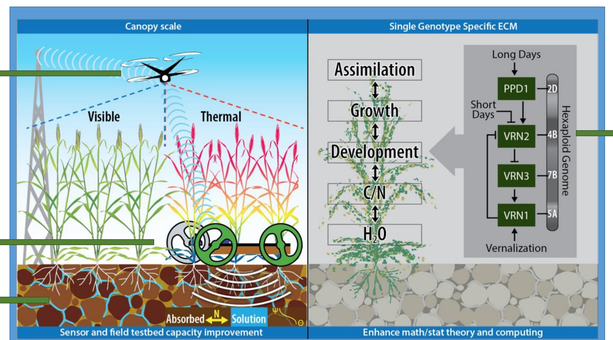


Single leaf with normals and 10,000 leaves in 3D.



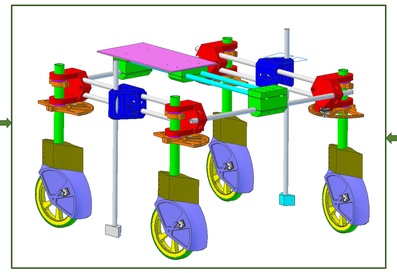


Mathematical formalisms will express model behaviors directly in terms of probability distributions (e.g. leaf segment area *vs.* height, left). Extant partial differential equation methods will evolve distributional moments through time, right). The forms of the models will be automatically evaluated to detect possible instances of non-identifiability. Genotype-specific parameter values will be estimated via genomic prediction methodology.



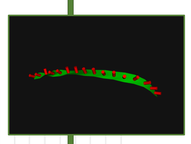
The central concept of this effort is to ***co-design*** models and field monitoring systems. That is, to view them as a single, self-reinforcing entity whose aim is genome-to-phenome prediction

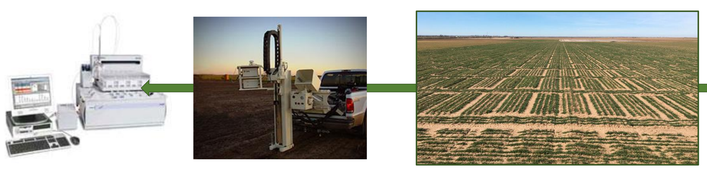
Langston undergraduates work remotely with K-State engineers on robot design evaluation and instrumentation planning.



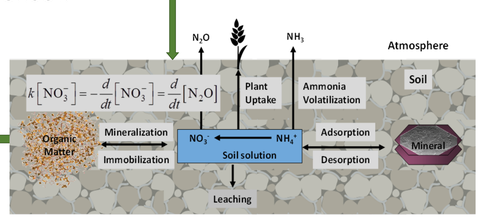
Current design for an in-field robot for transporting a multi-frequency electromagnetic soil nutrient and moisture sensor.

Insight into process control will be gained from network models based on time-series of RNA expression data from the field.

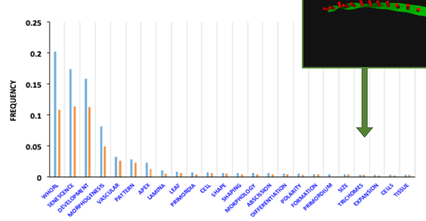




Multi-environment testing pipeline, with genotyped lines, instrumented soil core collection, and rapid lab processing units, all linked in real-time to georeferenced databases.



Differential equation model of nitrogen kinetics in the soil. These dynamics are influenced by water and temperature.



Project bioinformatics scans have found 788 wheat (orange) orthologs of leaf-related *Arabidopsis* (blue) genes.

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Partnering Academia, Industry, & Government to advance & secure Global Food Systems

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