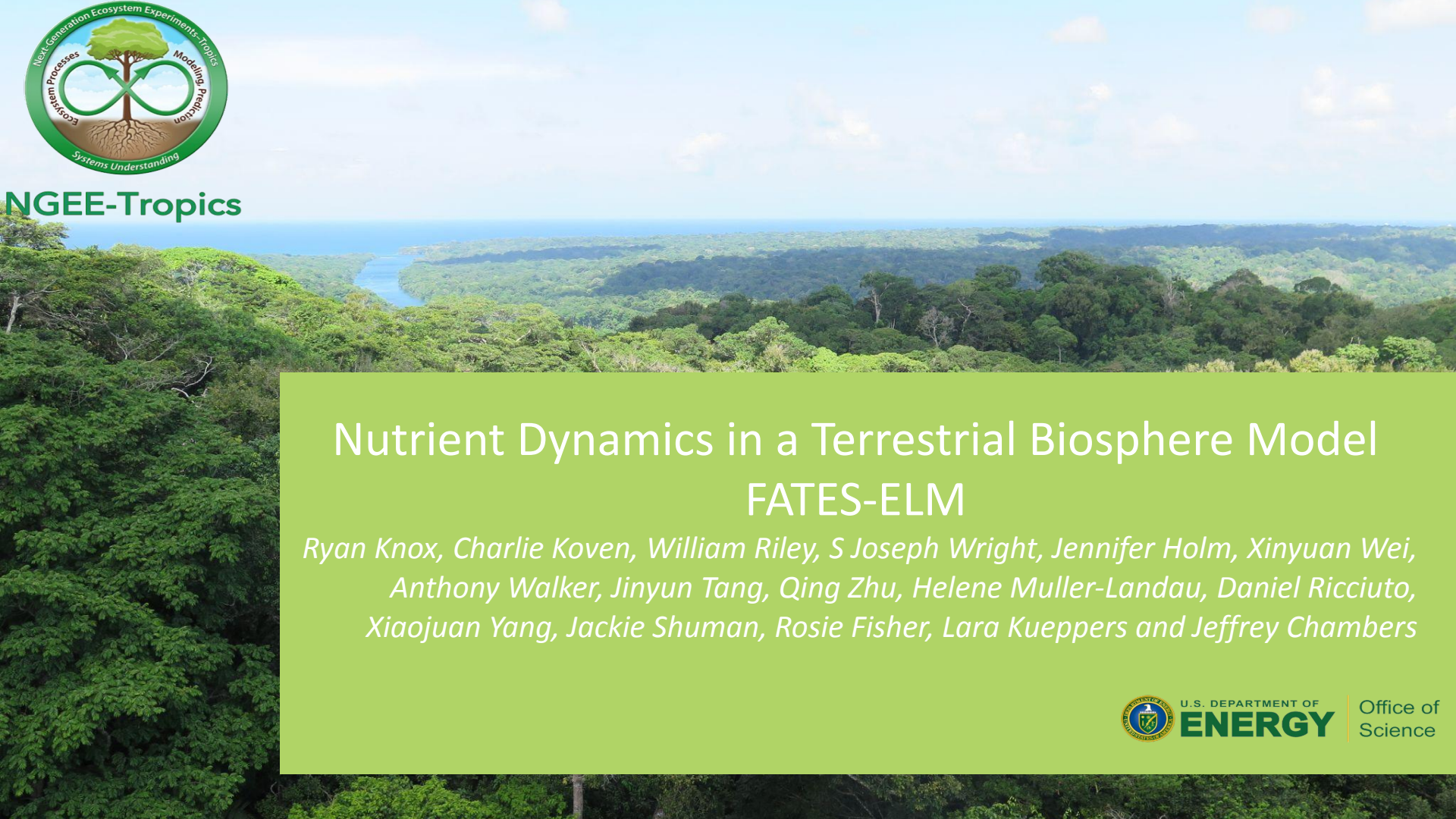

Nutrient Dynamics in a Terrestrial Biosphere Model FATES-ELM

Ryan Knox, Charlie Koven, William Riley, S Joseph Wright, Jennifer Holm, Xinyuan Wei, Anthony Walker, Jinyun Tang, Qing Zhu, Helene Muller-Landau, Daniel Ricciuto, Xiaojuan Yang, Jackie Shuman, Rosie Fisher, Lara Kueppers and Jeffrey Chambers

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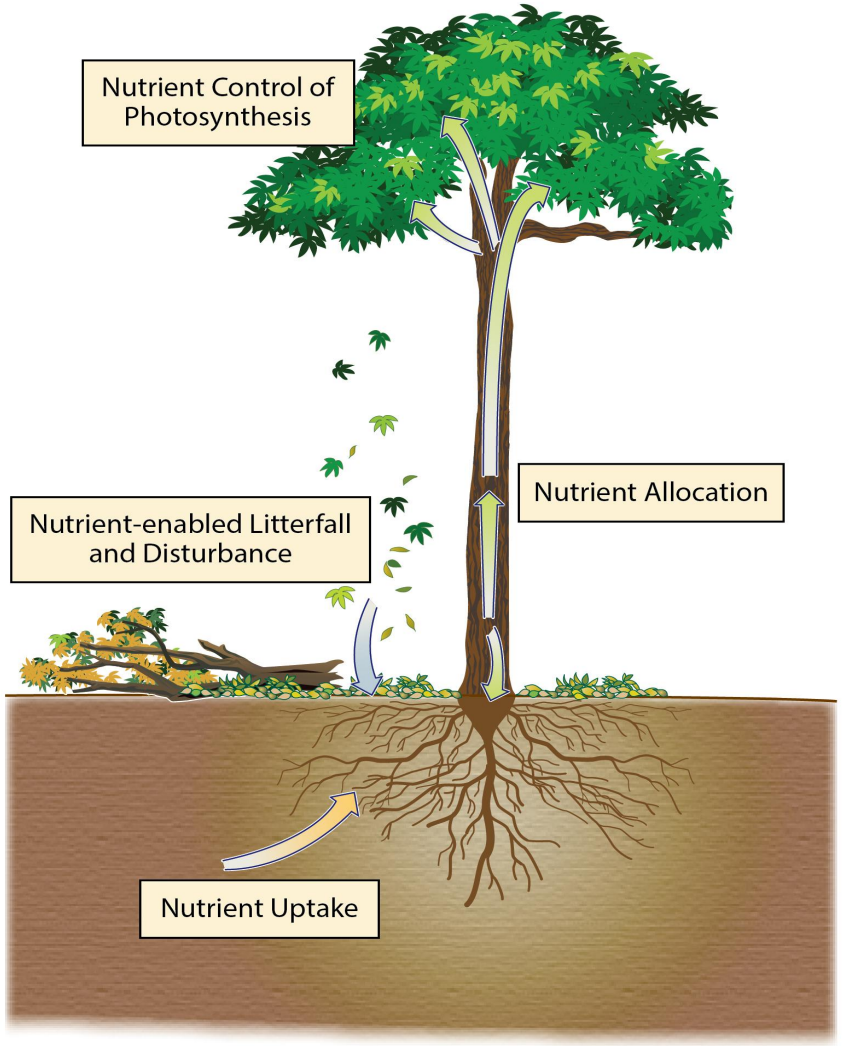
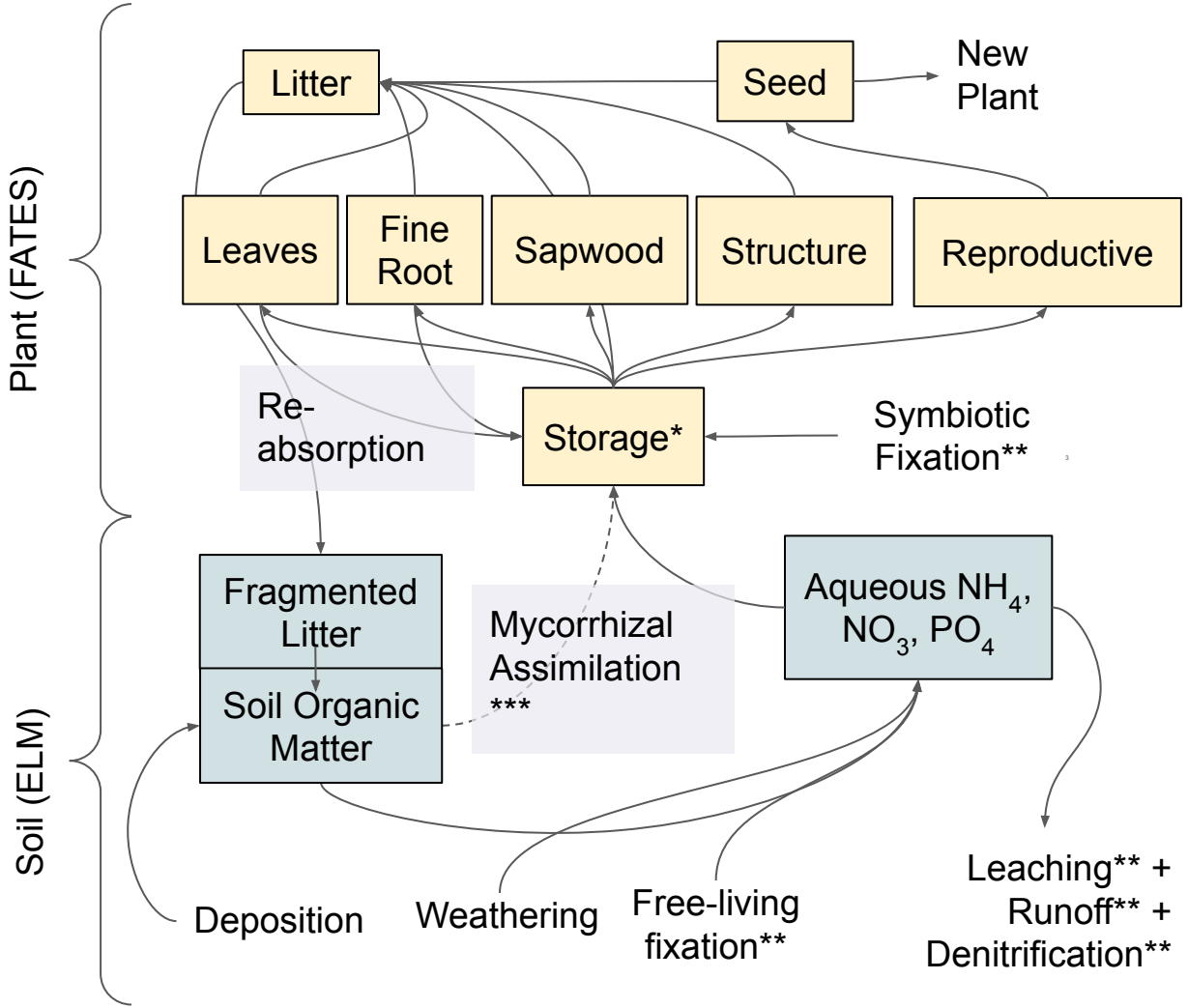
Model Description

1) Nitrogen (N) and phosphorus (P) are required to build plant tissues
2) Plant NH_4, NO_3 and PO_4 can be acquired through fine-root uptake
3) N can be generated through free-living fixation and obligate symbiotic fixation
4) Plant organ N concentrations affect respiration rates
5) N and P are passed back to the soil decomposition model through litterfall



EESA19-043

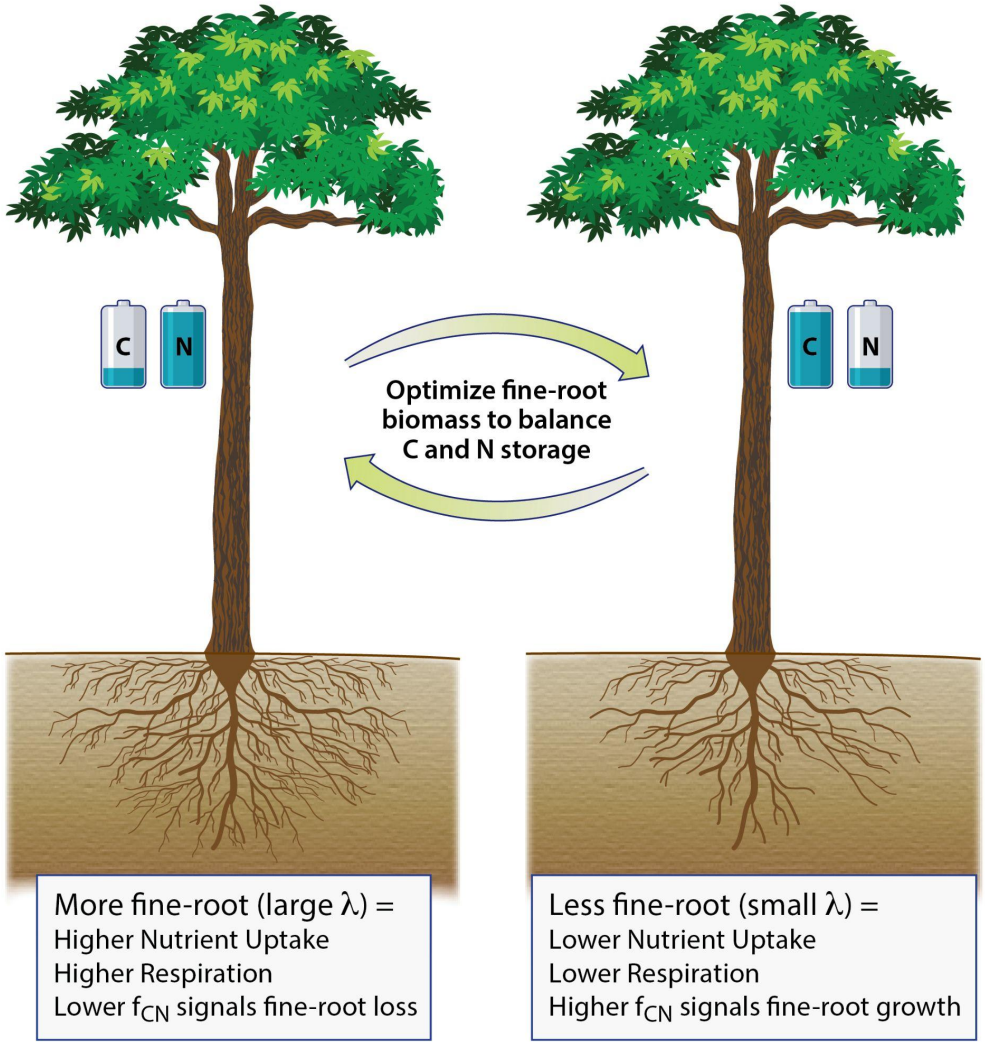
Model Description



Model Description: Uptake Regulation

$$\underbrace{\hat{M}_{u,NH_4(j)}}_{\text{Potential uptake soil layer j}} = \underbrace{\nu_{max,NH_4(pft)}}_{\text{PFT parameter constant}} \cdot \underbrace{C_{(fr,j)}}_{\text{Total fine-root biomass in soil layer j}}$$

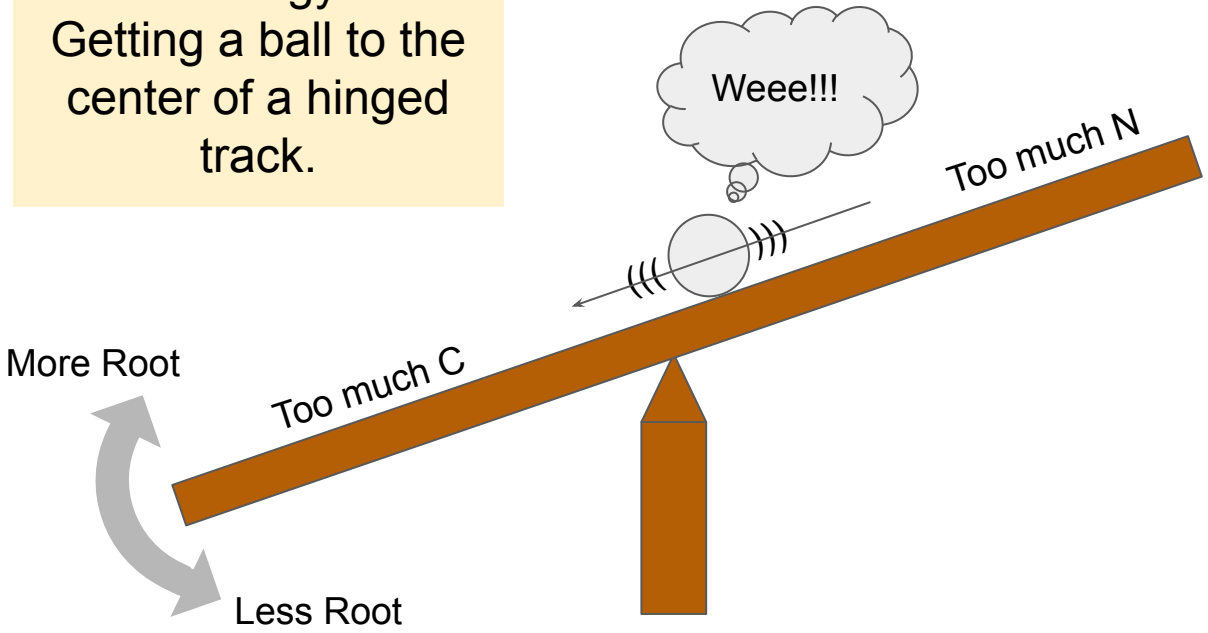
$$\underbrace{\grave{C}_{(fr)}}_{\text{Total fine-root biomass}} = \lambda \cdot \underbrace{\grave{C}_{(lf)}}_{\text{Total leaf biomass (from allometry) [kg/m2]}}$$



EESA23-007

Model Description: Uptake Regulation

Analogy:
Getting a ball to the center of a hinged track.



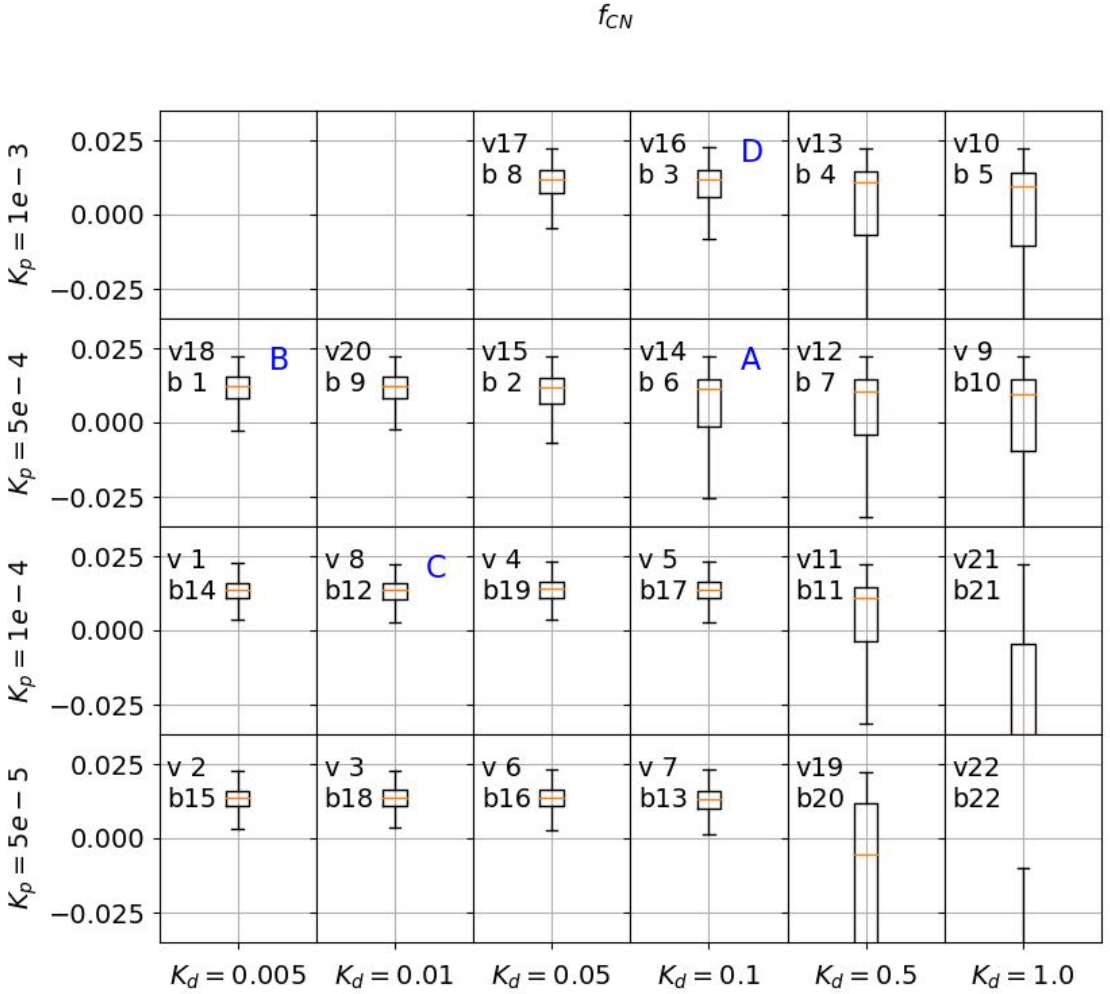
$$f_{CN} = log\left(\frac{C_{store}/C_{store,max}}{N_{store}/N_{store,max}}\right)$$

Position of the ball

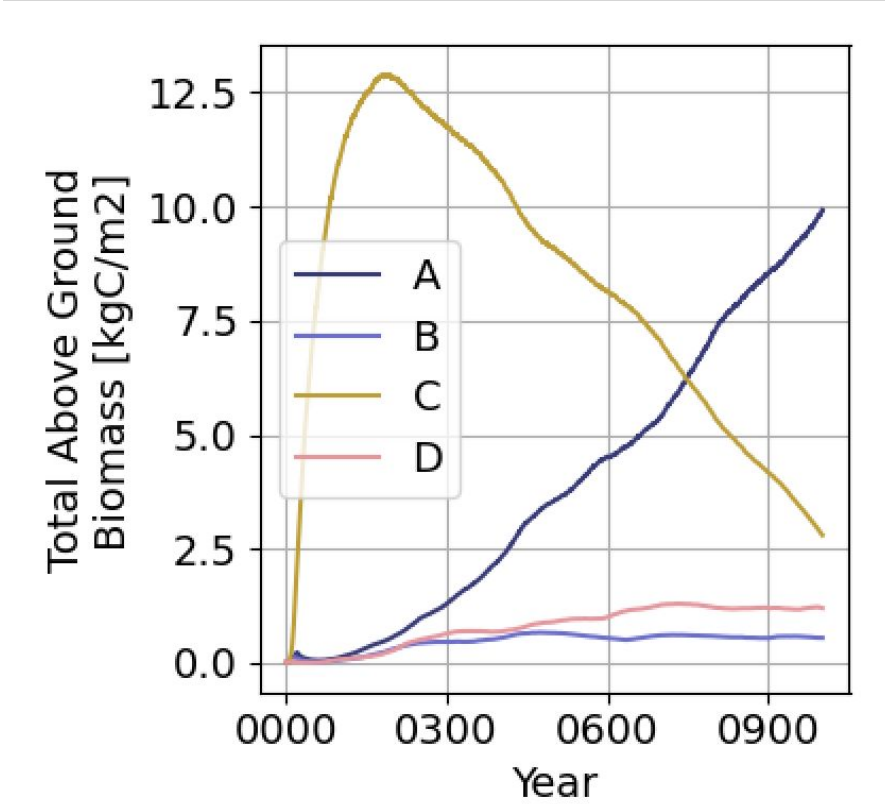
Proportional Integral Derivative (PID) Controller:

$$\lambda_t = \lambda_{t-1} + K_{p(pft)} f_{cn} + K_{i(pft)} \int f_{cn} dt + K_{d(pft)} \overline{\frac{df_{cn}}{dt}}$$

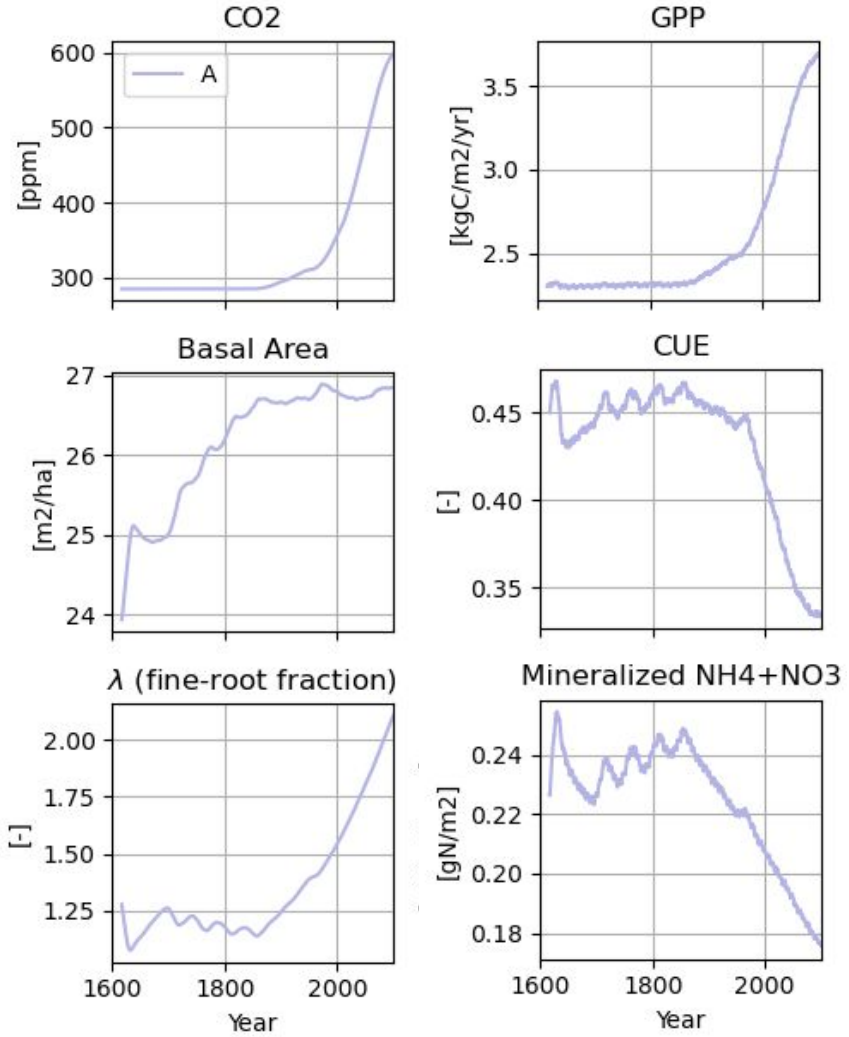
Calibration: PID
K_p & K_d



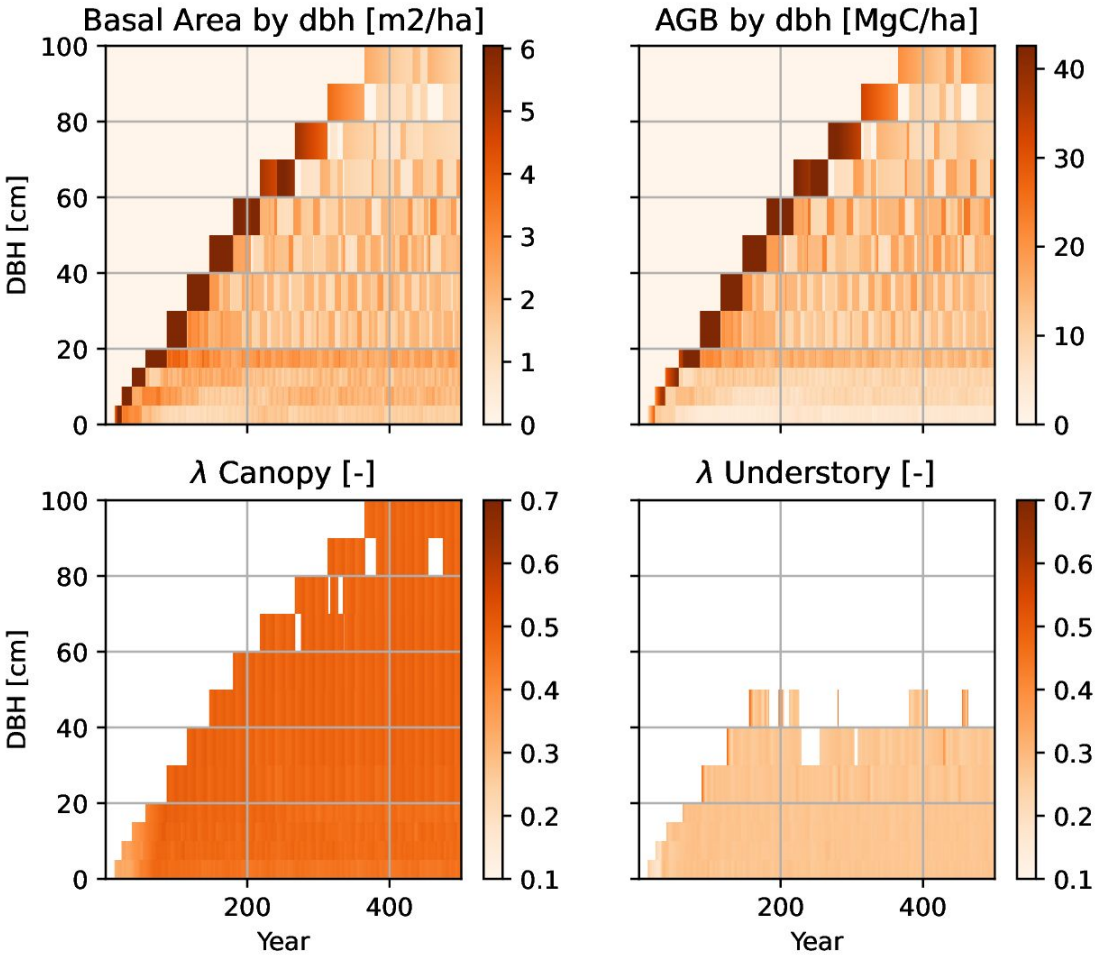
Calibration: PID
K_p & K_d



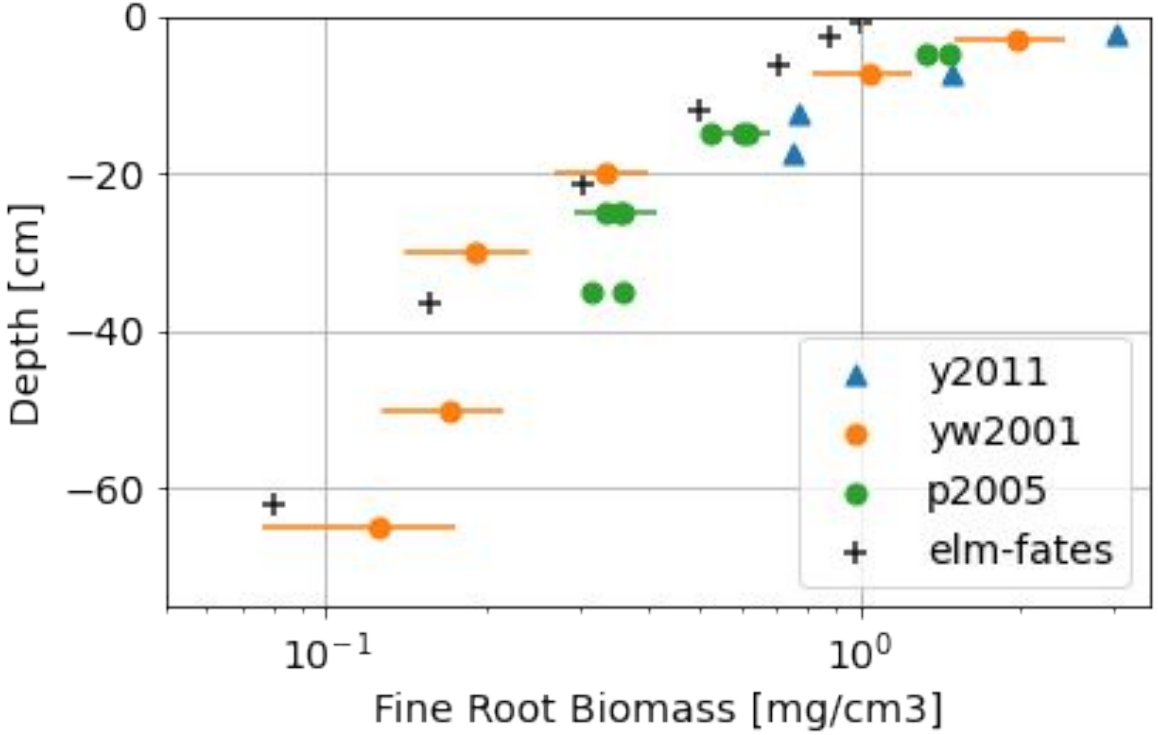
Nitrogen limits growth + competition for nitrogen reduces carbon use efficiency



Trait plasticity (in roots) creates new survival niche for understory plants



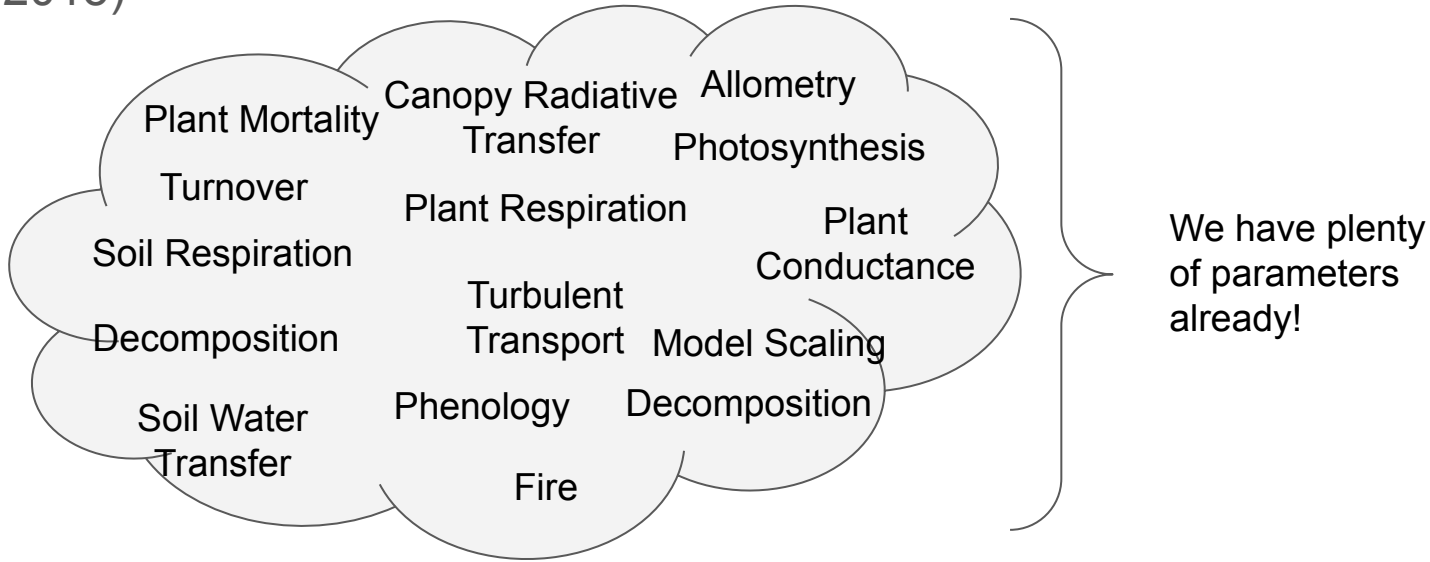
Fine-root biomass comparisons are useful but with caveats



Mean fine-root biomass profiles at the Barro Colorado National Monument from Yavit et al. 2011, Yavitt and Wright 2001, and Powers et al. 2005. Data available via Iversen et al. 20xx (FRED3).

A Simplicity Imperative

"*As more processes continue to be identified and included in LSMs, the almost universal tendency is for LSMs to become more and more complex. A worrying side-effect is the progressive introduction of more model* ***parameters*** *with (commonly) substantially uncertain values... Complexity needs to be balanced*." (Prentice 2015)



Key (new) Model Parameters

Parameter(s)	**Model Sensitivity**	**Availability**
ν_{max} (NH4,NO3,PO4)	High	Calibrated
Leaf Reabsorption Fraction	High	Readily Observable
P Organ Stoichiometry	High	Mostly Observable
PID Kp, Ki, Kd	Medium	Calibrated
N & P Storage Capacity and Variability	Medium & Low	Difficult & Scaling Rules
Symbiotic Fixation cost and efficiency	High	Literature

Current and Potential Work

Explicit representation of mycorrhizae

Differentiated passive and active root uptake

Variable affinity and regulated transport systems (facultative active uptake)

Facultative symbiotic nitrogen fixation

Covariance of N and P in uptake and regulation

Current: Couple with FATES nutrients with CTSM

Thank You

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We also thank the strong domestic and international collaborations across numerous universities and research organizations that make our efforts possible.

NGEE–TROPICS
NEXT-GENERATION ECOSYSTEM EXPERIMENTS–TROPICS

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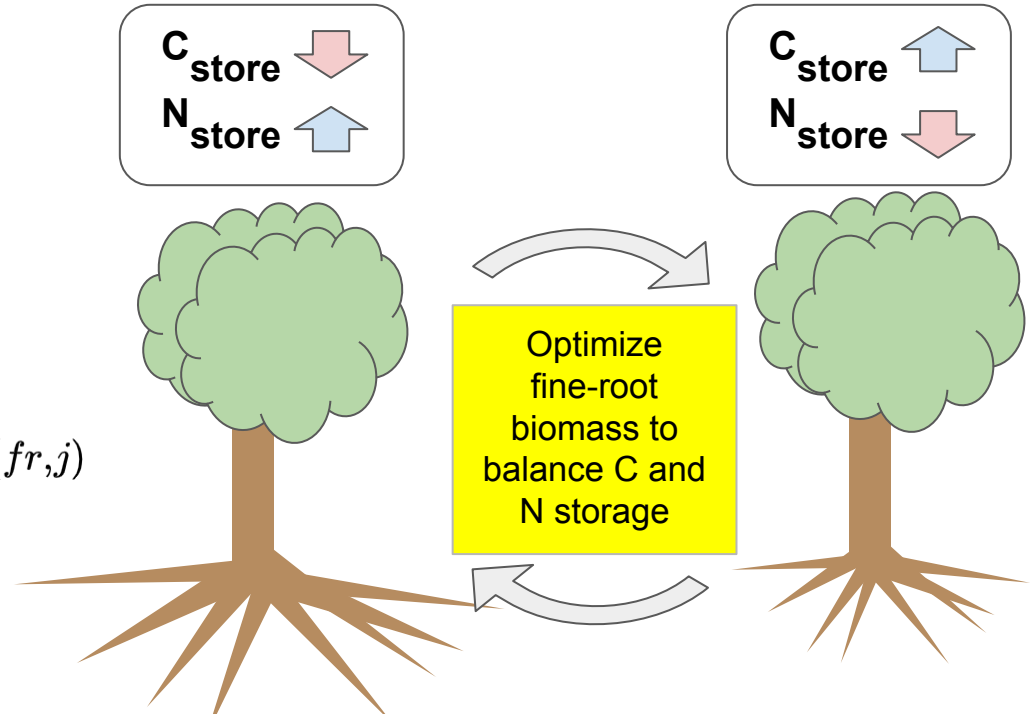
Model Description: Uptake Regulation

$$\hat{M}_{u,NH_4(j)} = \nu_{max,NH_4(pft)} \cdot C_{(fr,j)}$$



More fine-root $(\text{large}\lambda)$ =
Higher Nutrient Uptake
Higher Respiration
Lower f_{CN} signals fine-root loss

Less fine-root $(\text{small}\lambda)$ =
Lower Nutrient Uptake
Lower Respiration
Higher f_{CN} signals fine-root growth