

# Carbon allocation to reproduction: leverage on forest structure & demography

preliminary findings from the CLM-FATES  
Tree Recruitment Scheme (TRS) at Barro Colorado Island, Panama

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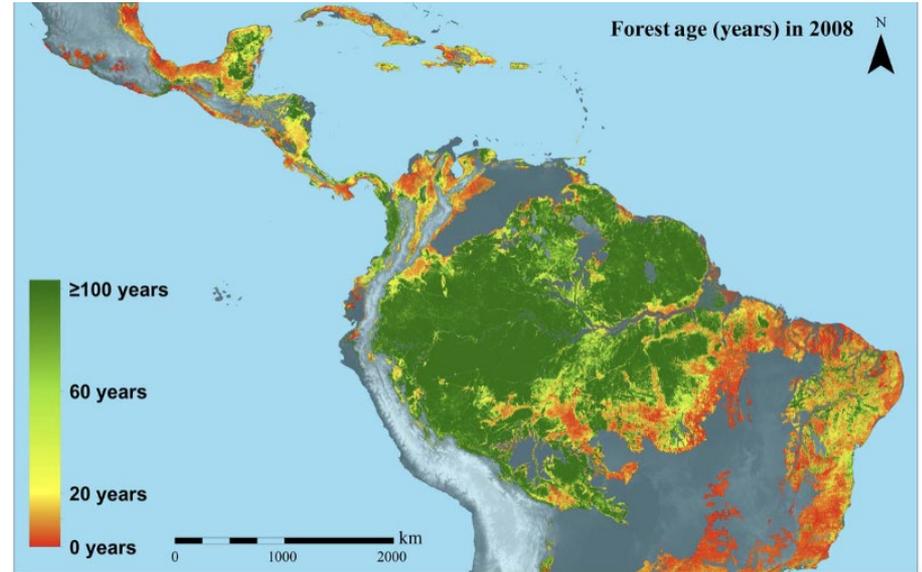
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*Thanks to Jessica Needham, Ryan Knox, Joe Wright, Helene Muller-Landau,  
DOE-SCGSR, NGEI-Tropics, NCAR, FATES teams*



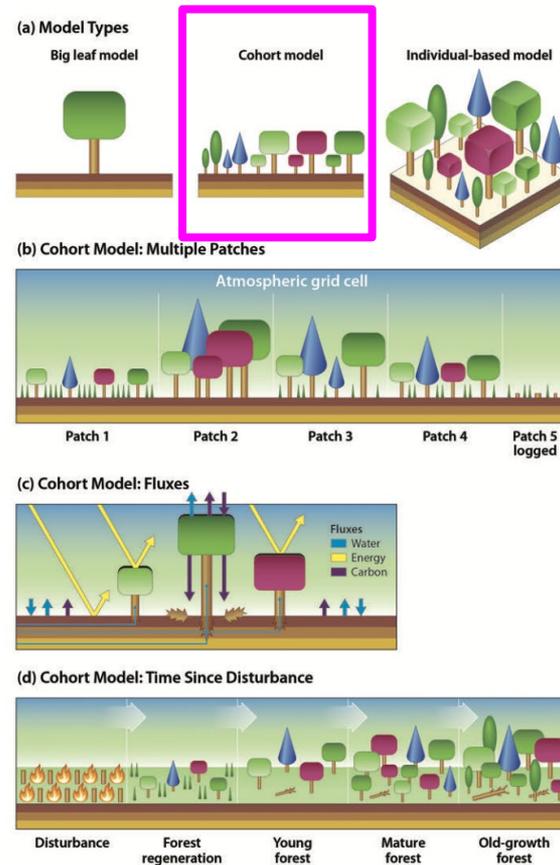
## Regeneration is critical to future forests

To predict forest responses and feedbacks to global change, **FATES** needs to be able to **simulate where and what types (PFTs) of trees are able to regenerate** in a given set of environmental conditions



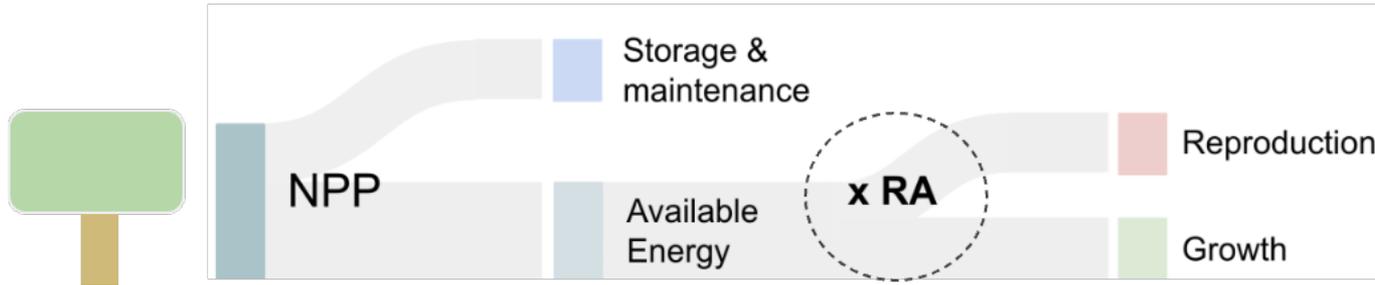
(Chazdon et al., 2016)

FATES is a cohort based  
vegetation demographic model  
(VDM) coupled with a host land  
model (CLM)



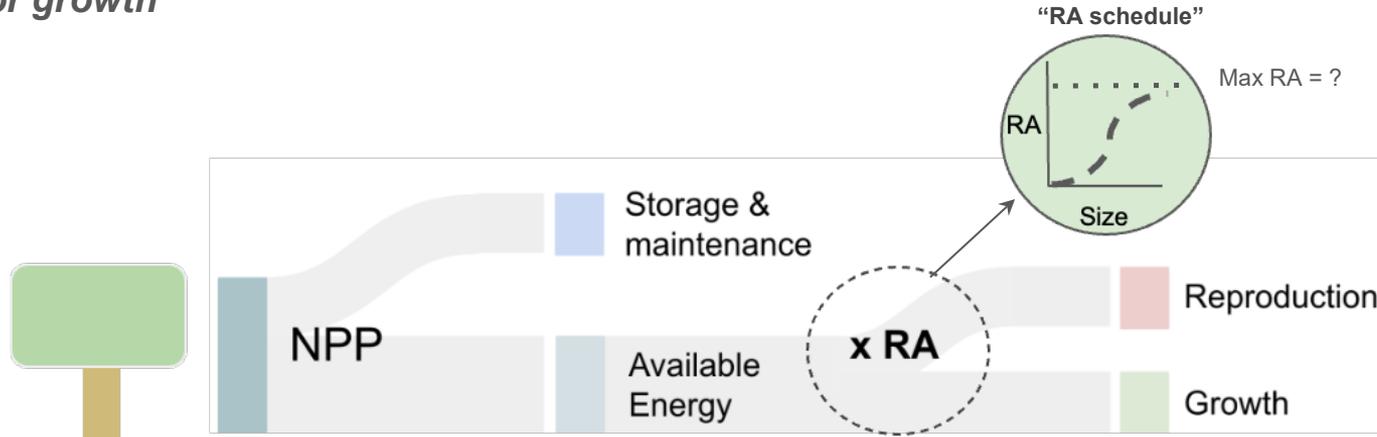
# Why do we expect reproductive processes to influence forest structure and demography?

*The first step of reproduction, reproductive allocation (RA), exhibits a well-supported **tradeoff with carbon for growth***

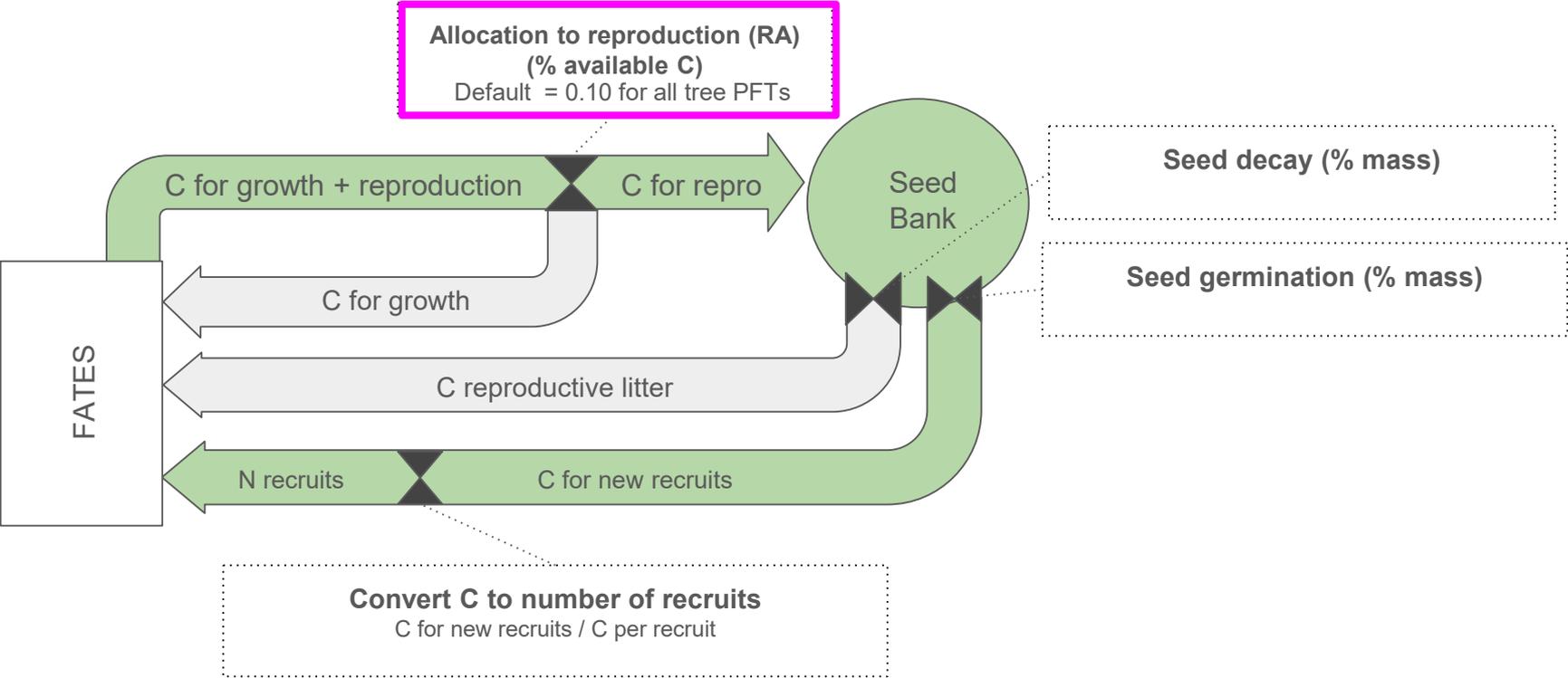


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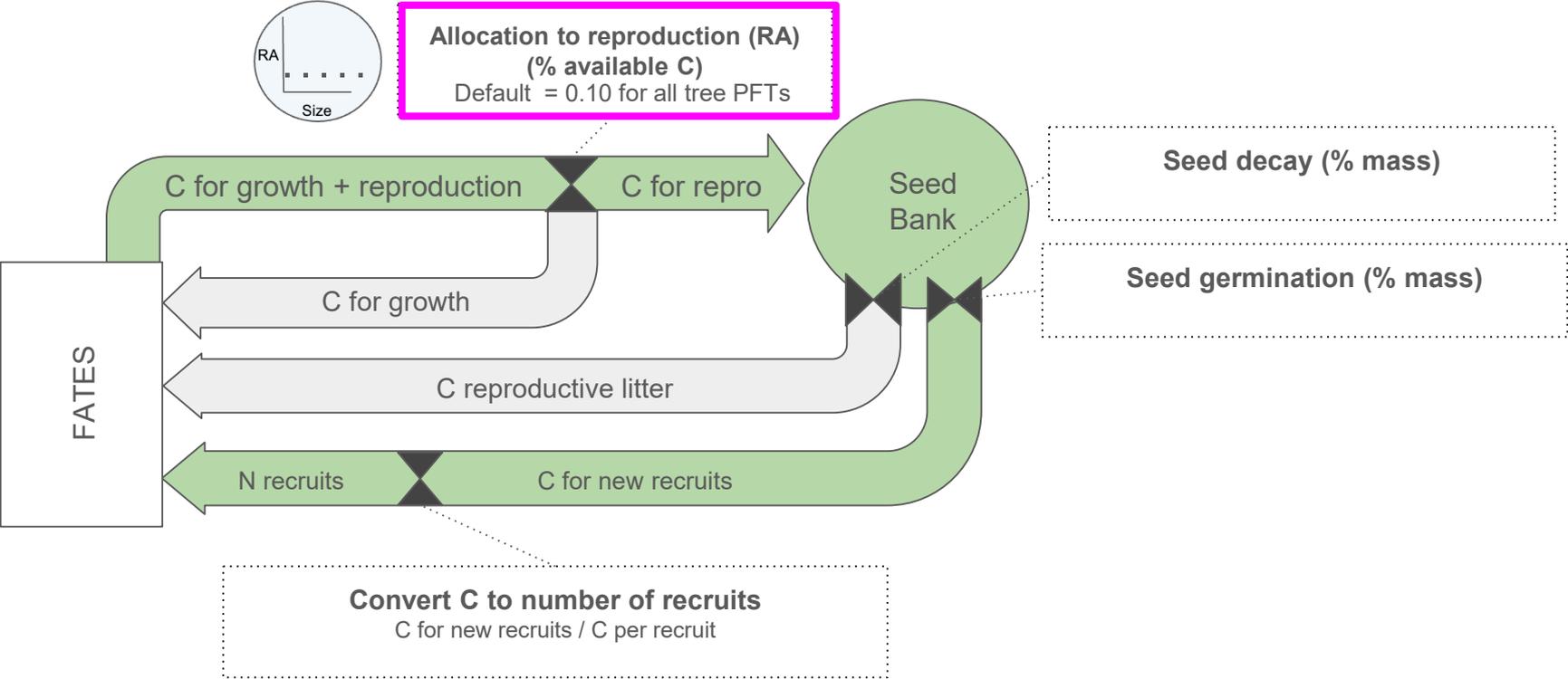
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# FATES default regeneration (tree PFTs)



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# New work shows RA increases ~60% from boreal to tropical forests, and with forest age

*Dataset and litterfall proxy for RA provide practical ecosystem-scale benchmarks for modelers*

ECOLOGY LETTERS

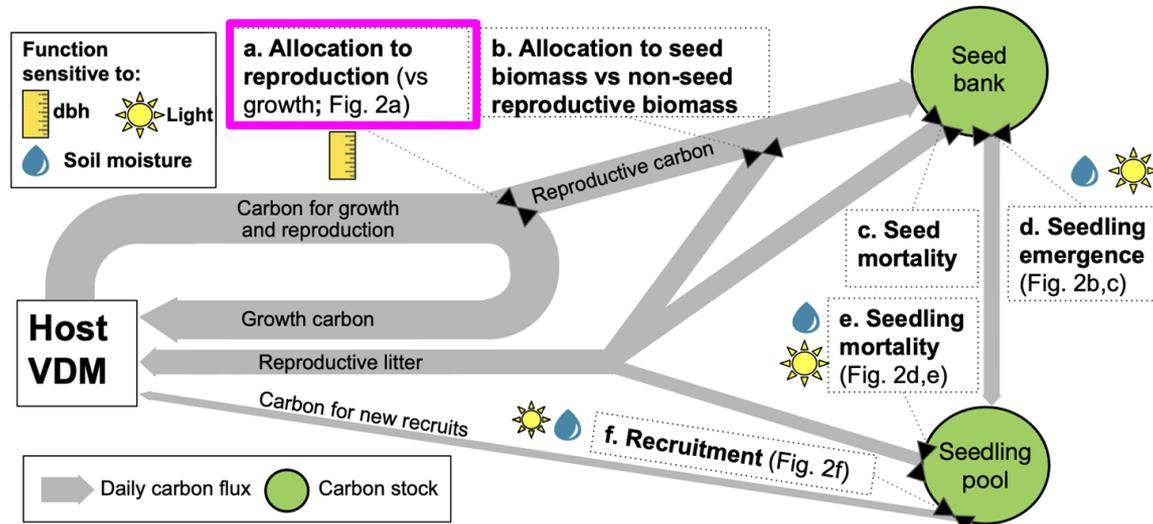


SYNTHESIS **OPEN ACCESS**

## Forest Age Rivals Climate to Explain Reproductive Allocation Patterns in Forest Ecosystems Globally

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The new(ish) **FATES Tree Recruitment Scheme (TRS)** can represent size-dependent reproductive allocation (RA) and environmentally sensitive recruitment, but is relatively untested



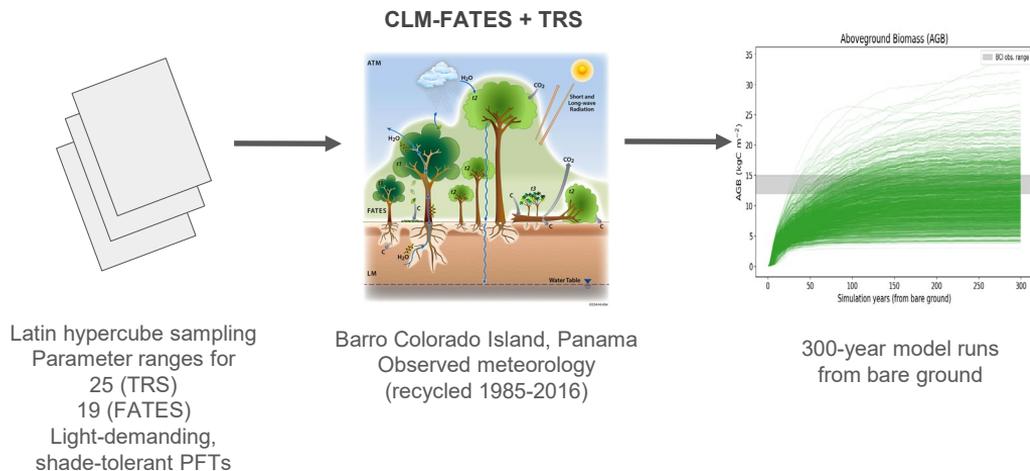
Hanbury-Brown et al. (2022)

# Objectives

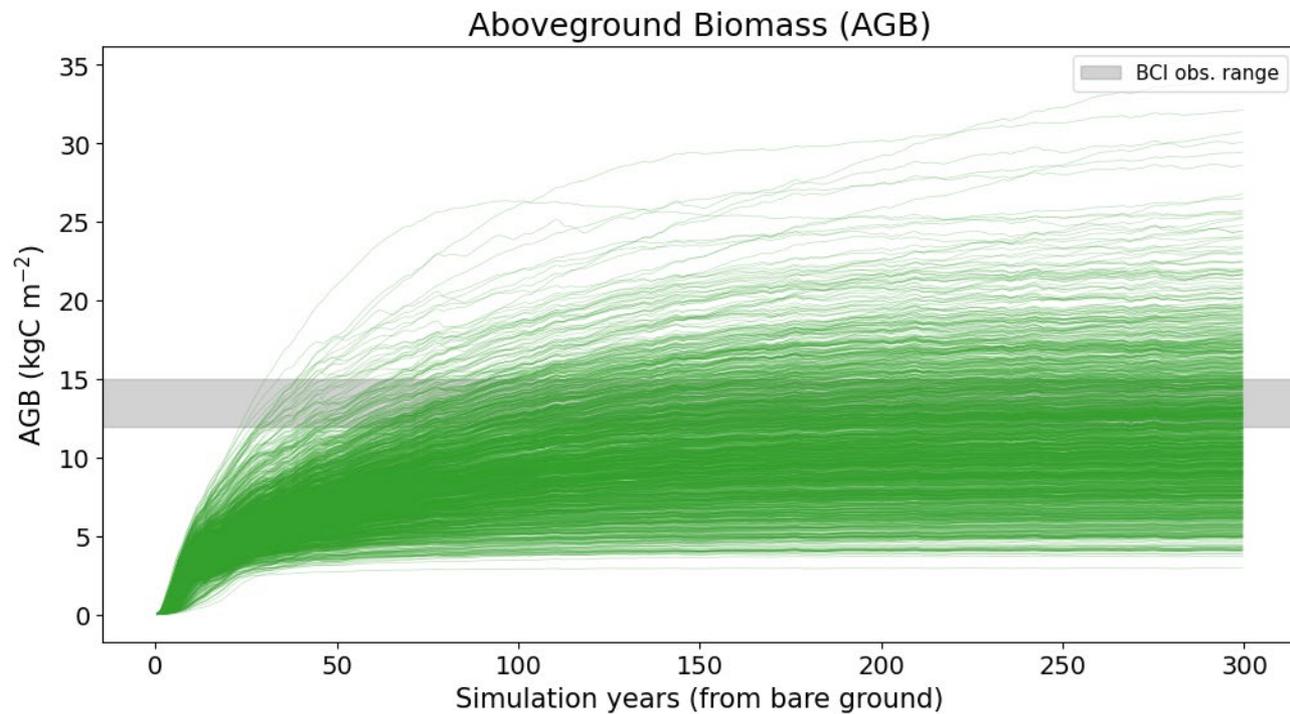
1. Identify sensitivity of model predictions to TRS parameters
2. Develop working parameterizations for light-demanding and shade-tolerant plant functional types at Barro Colorado Island, Panama
3. Assess the leverage of regeneration strategies on structure, demography and relative abundance.

## Methods:

1400 member ensemble parameter perturbation experiment

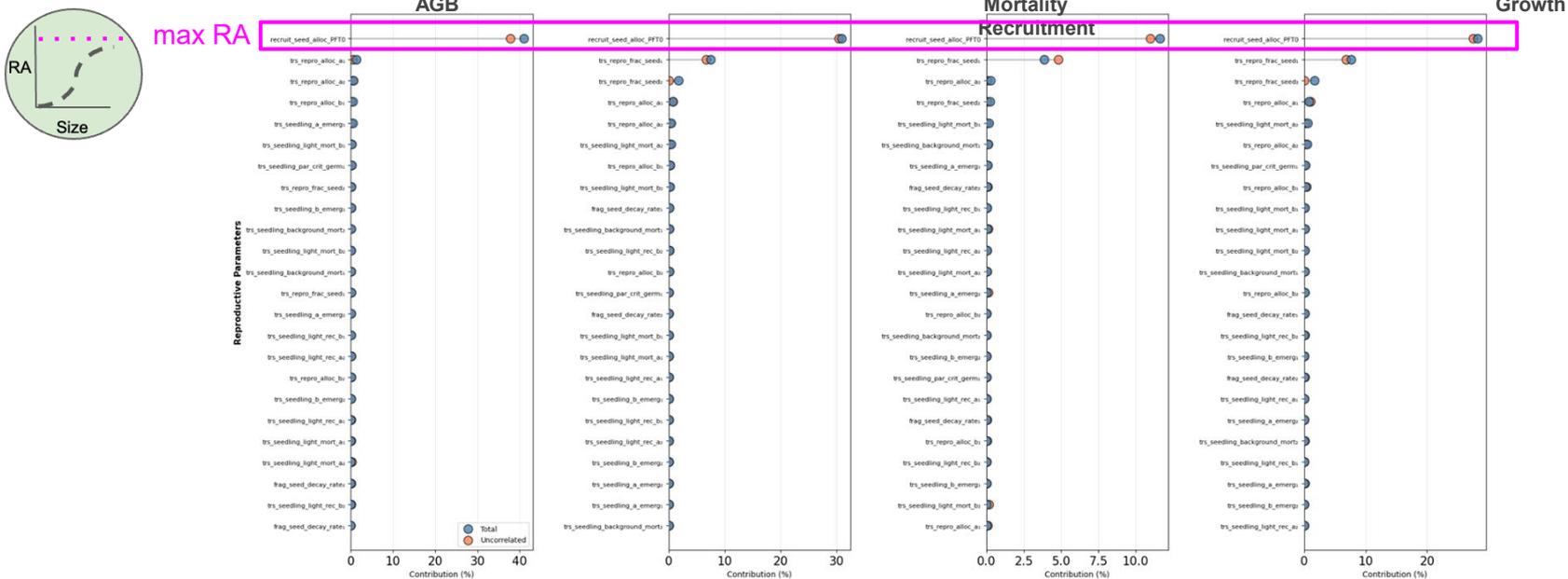


## Preliminary results:



# How sensitive are demographic outcomes to TRS parameters?

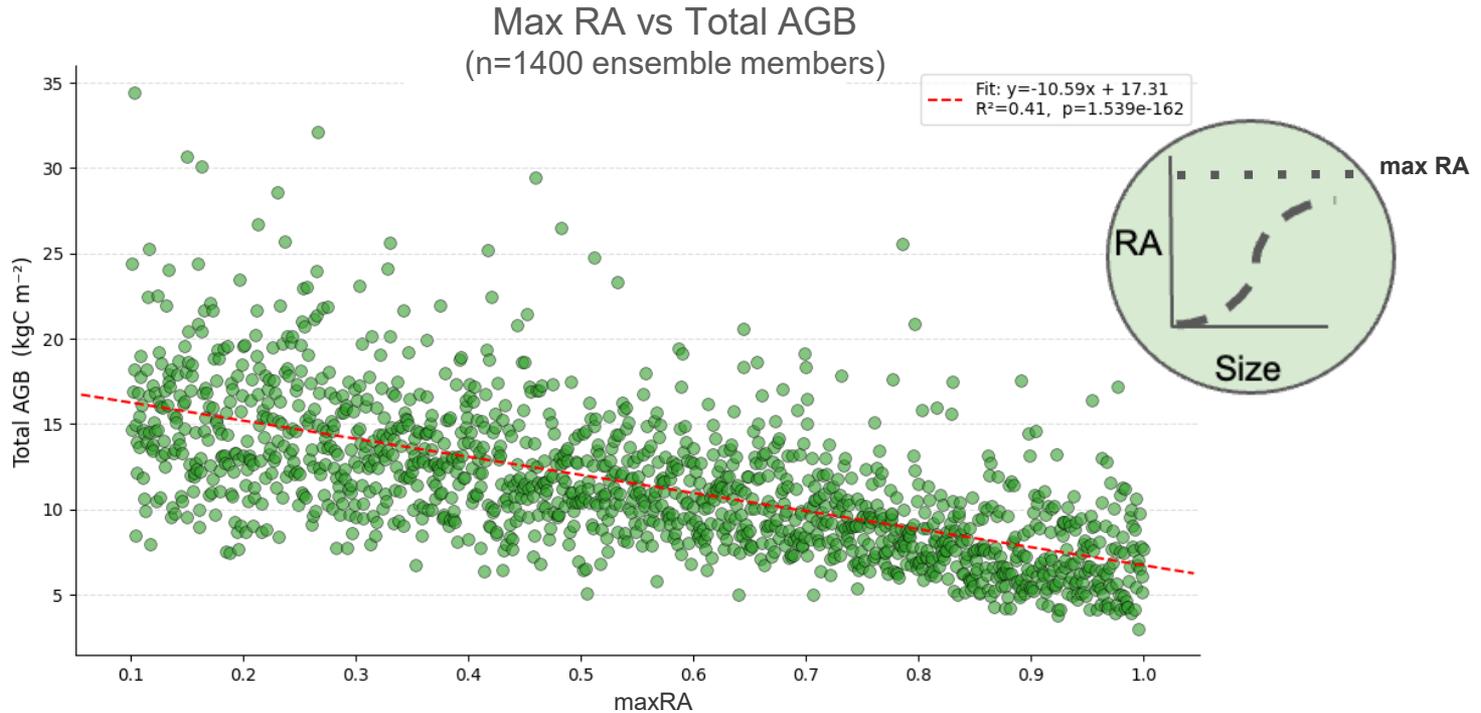
*The max reproductive allocation (RA) parameter explains ~40% variation in ensemble AGB, and is the TRS parameter with the strongest leverage on all demographic rates*



Regression model sensitivity analysis following Xu and Gertner (2008); Cheng et al., (2021)

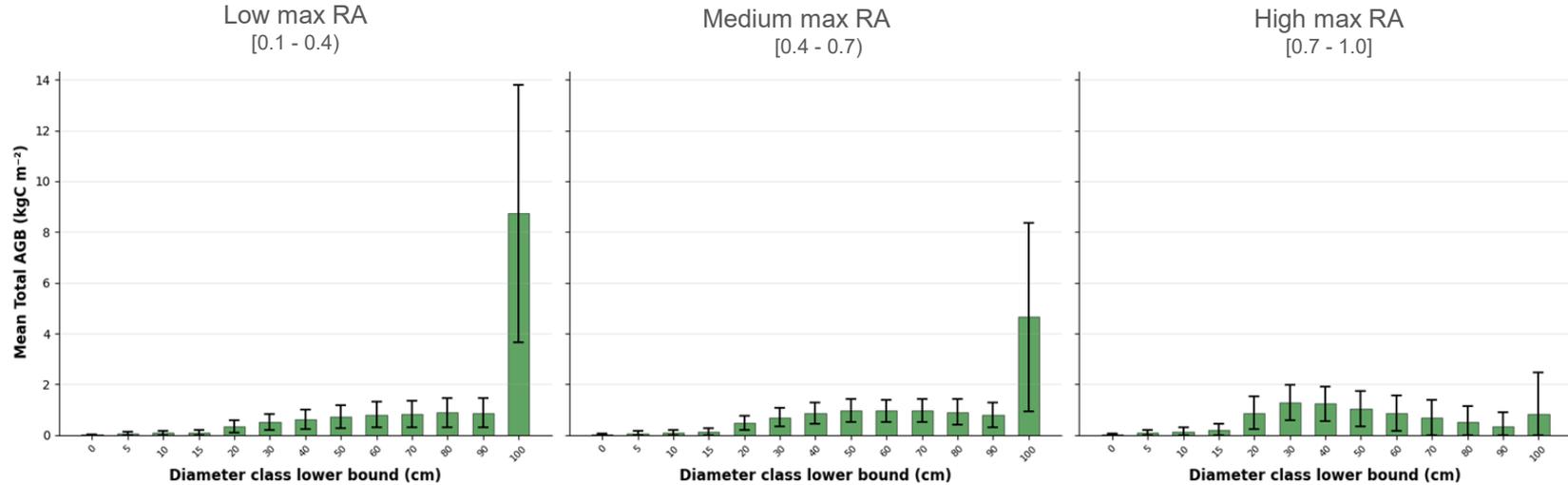
# Max RA has a negative linear relationship with AGB

*~ 0.1 increase in max RA = ~1 kgC/m<sup>2</sup> decrease in AGB*

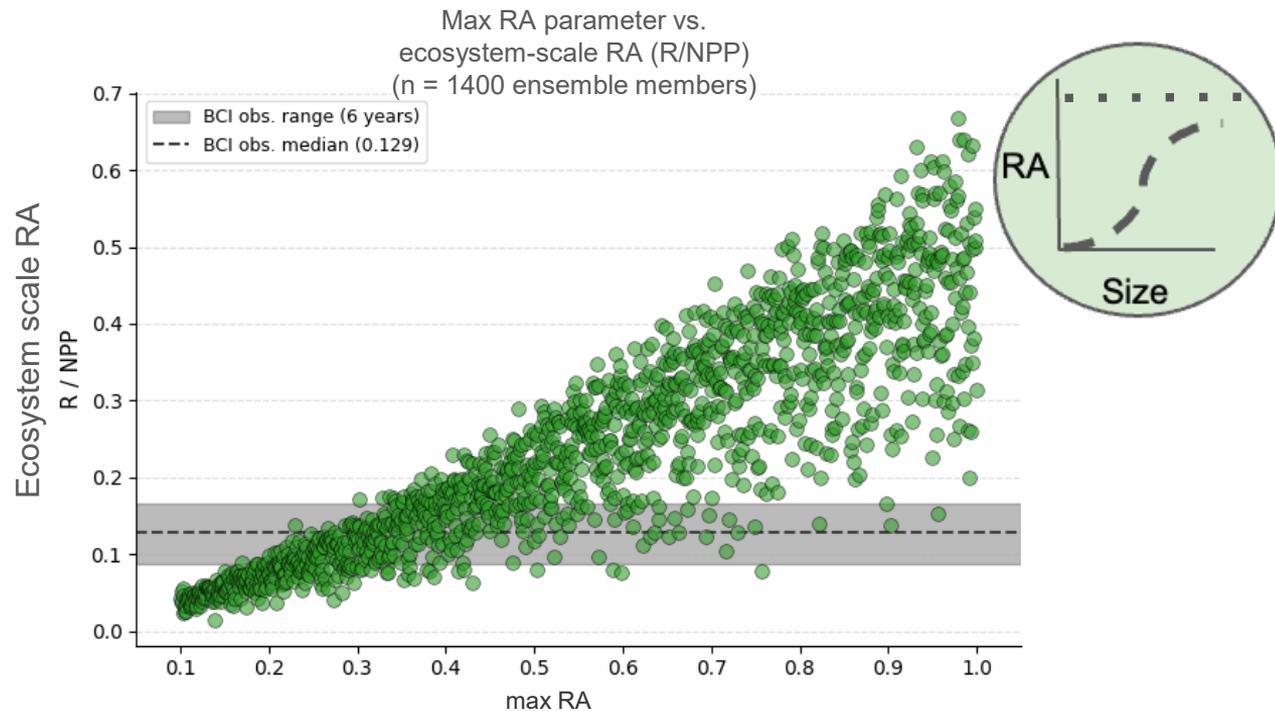


Differences in AGB are largely due to biomass in the largest size class:

Ensemble mean AGB by size class over max RA levels

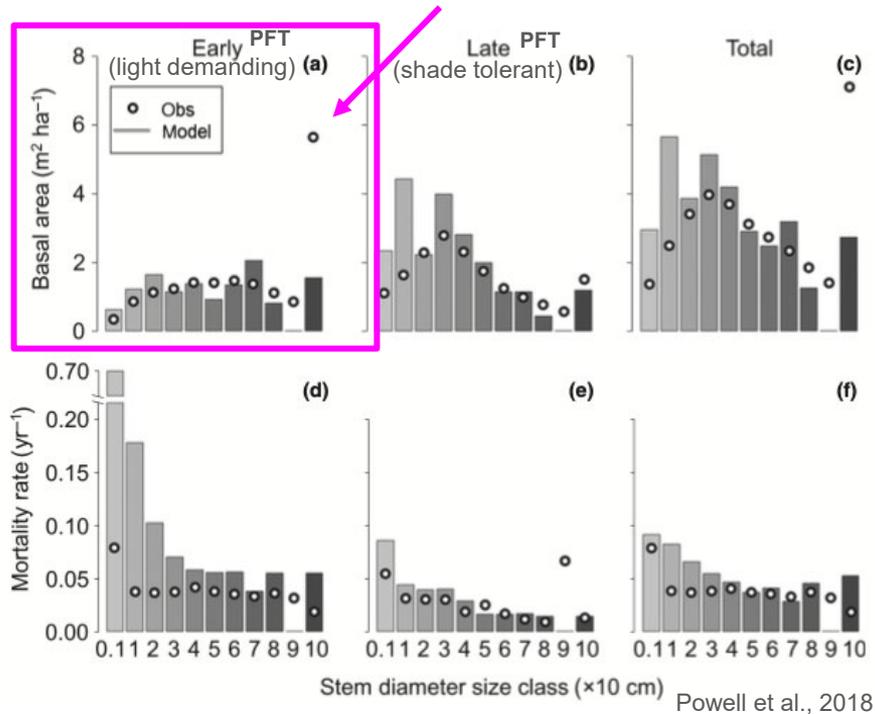


Next steps: compare ensemble member predictions with observed benchmarks, retain best performing parameter sets



# Are PFTs with distinct reproductive strategies needed to match observed forest structure?

Long Lived Pioneers have high growth, low RA



Powell et al., 2018

# Takeaways

## Reproductive allocation (RA) varies over biomes and forest age

→ *ecosystem scale RA benchmark can be estimated from litterfall (Ward et al. 2025)*

**FATES-TRS** can mechanistically represent reproductive strategies, work to parameterize is ongoing!

→ *Max RA parameter is a dominant control on AGB, size structure, demographic rates*

→ *Getting RA right matters for predictions, especially size structure*

*Thanks to Lara Kueppers, Marcos Longo, Jessica Needham, Ryan Knox, Joe Wright,  
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