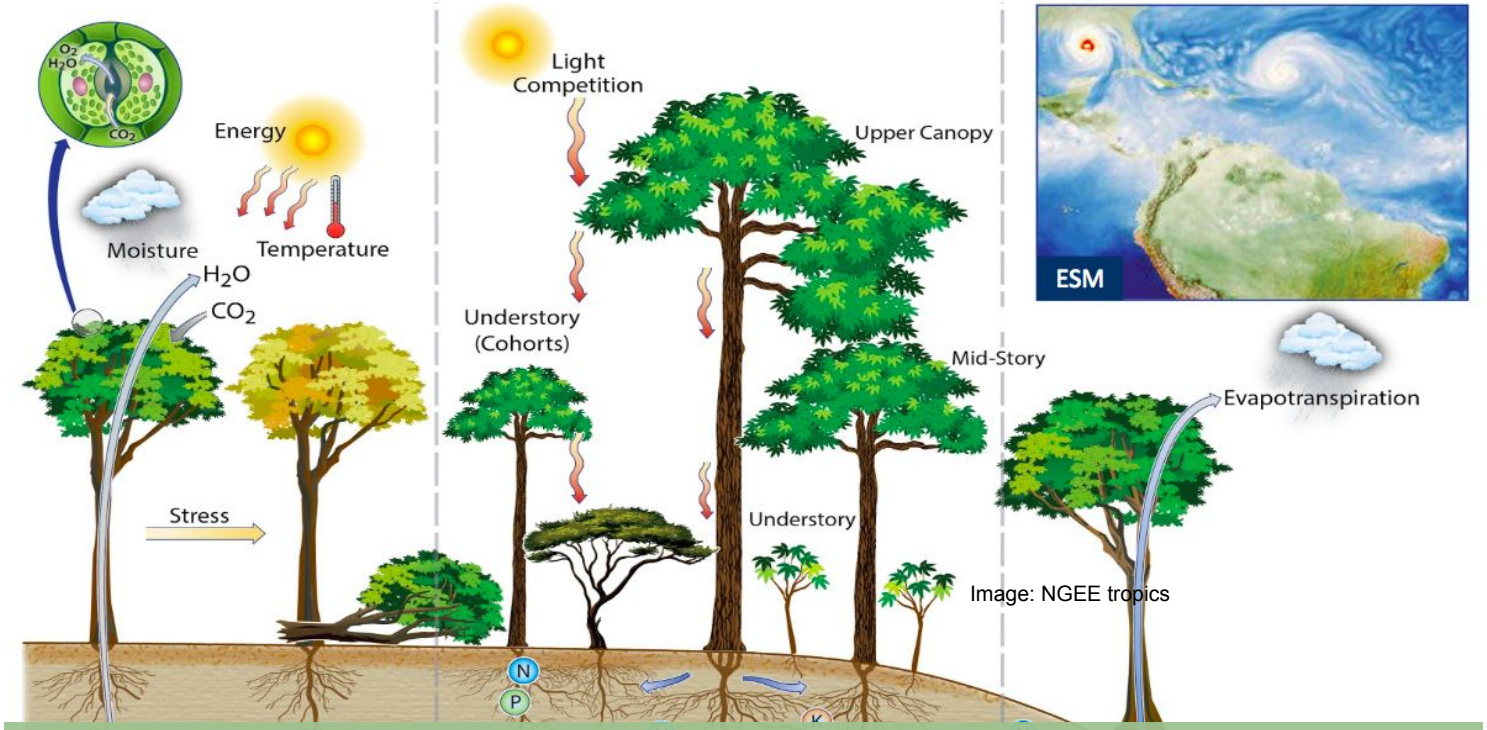
# Reduced complexity modes as a "gateway drug" to FATES




**Rosie Fisher (NCAR/CERFACS)**

CESM Land Model Working Group, June 2020.

**Thanks to:Charlie Koven Ryan Knox, and the FATES developers.**

# Reduced complexity modes as a "gateway drug" to FATES

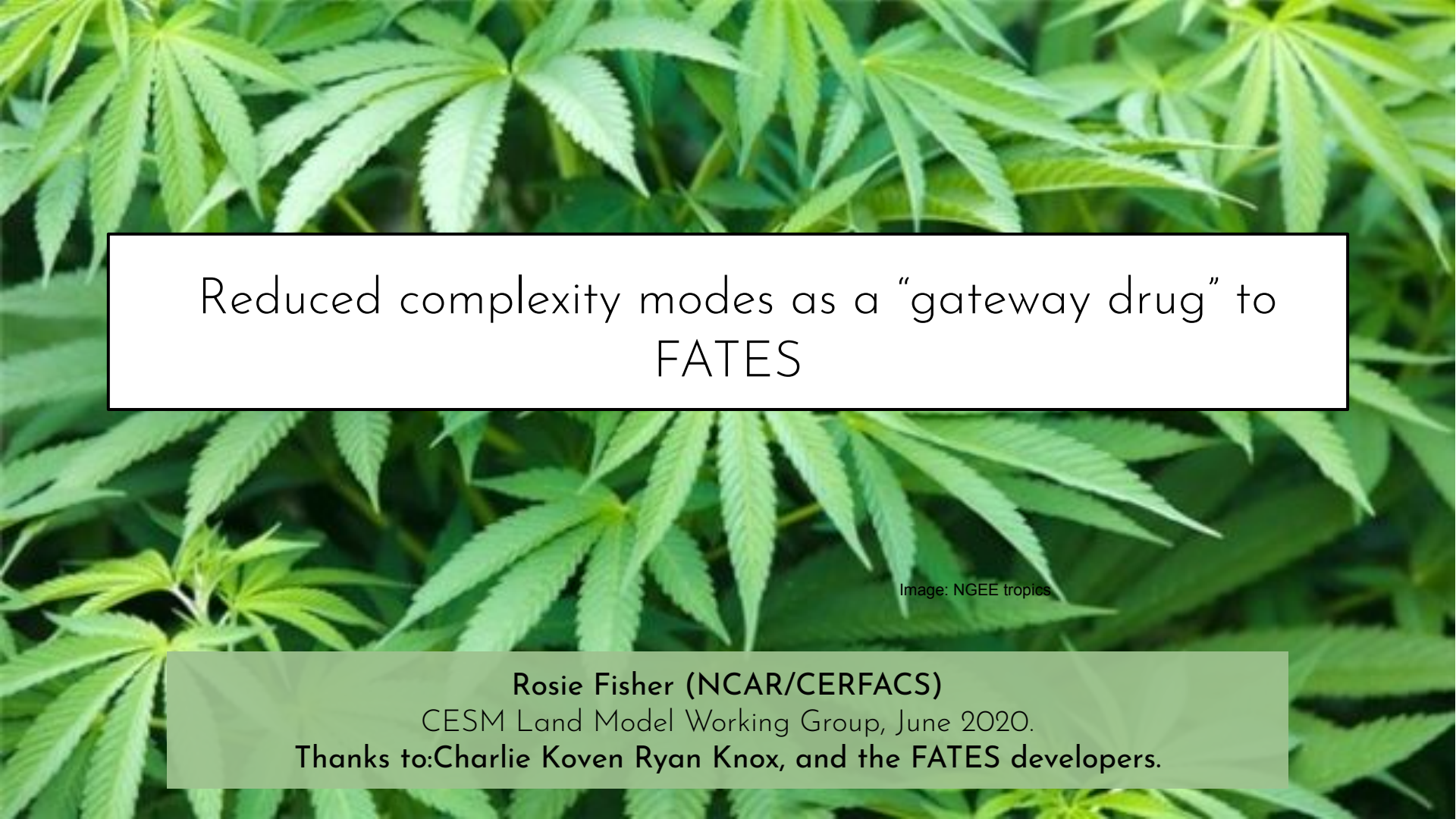


Image: NGEE tropics

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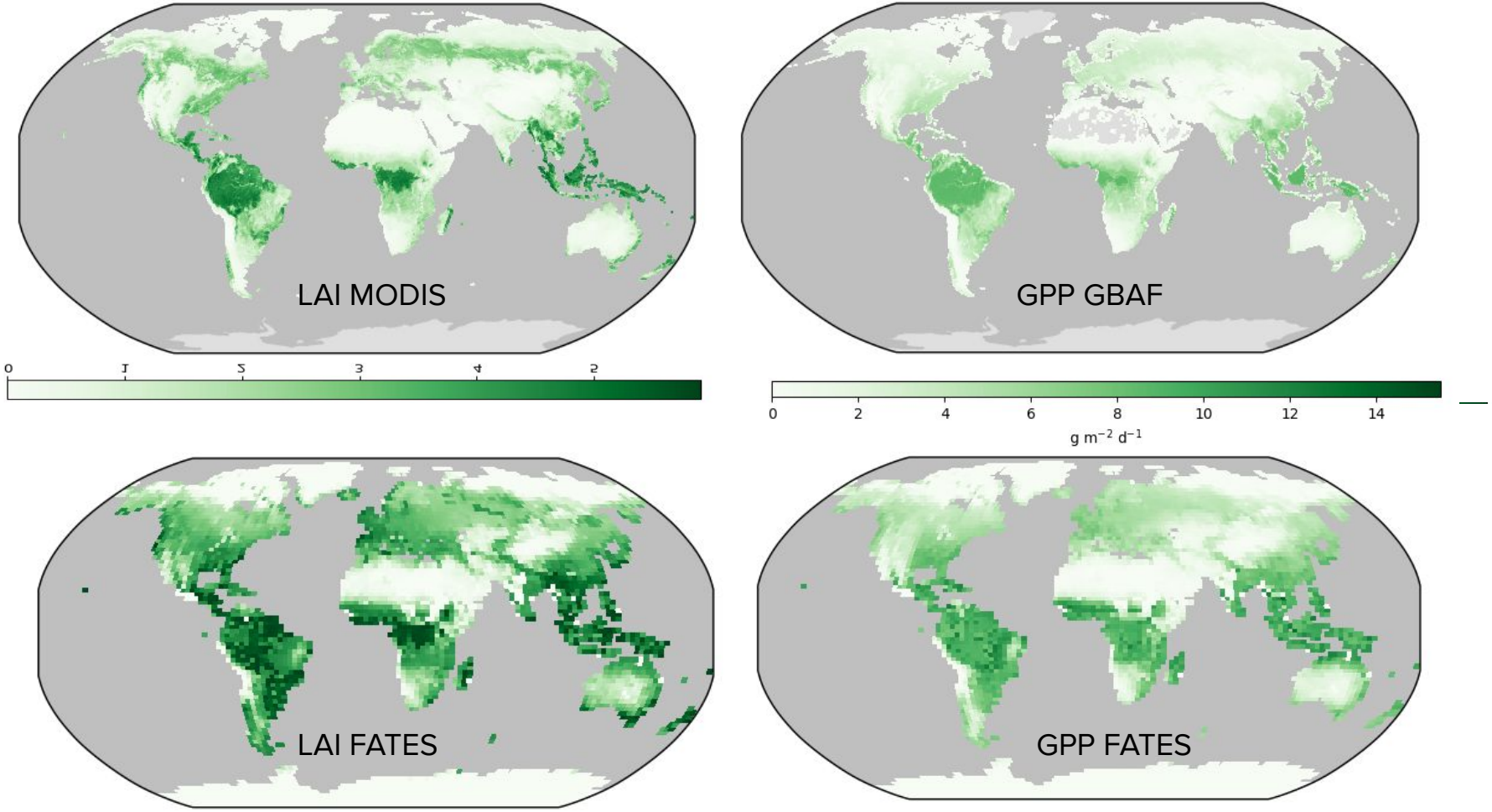
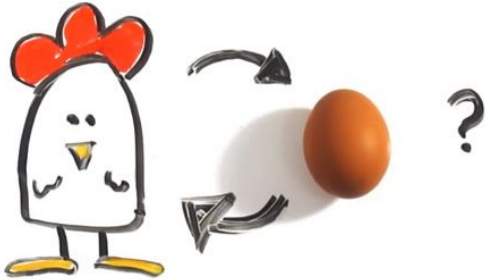
ILAMB diagnostics at http://fsc2.net/rosie/test1/

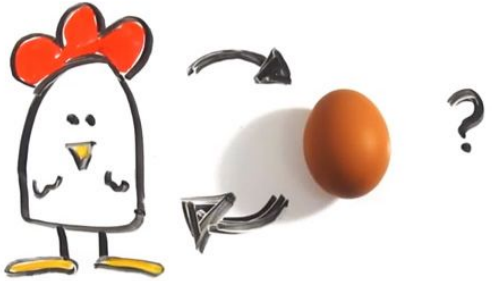


# Context: How to fix a High Bias?



- FATES global runs currently have **high LAI and GPP biases**
- This is a 'chicken and egg' problem.
- We could fix it by reducing **GPP per unit LAI,** or **LAI per unit GPP**
- A **'satellite phenology' (SP)** version of FATES, with **proscribed leaf area index** would help disentangle these biases

# Context: How to fix a High Bias?



- On the way to 'FATES-SP' mode, we need:

- 1. **Fixed biogeographic distributions** of plant functional types
- 2. **Fixed patch areas** for given plant functional types (turning **off** vegetation competition dynamics)

These modifications provide the opportunity to generate interesting and useful ways of running FATES.

# Why a ‘gateway drug’?

- “Reduced Complexity Modes” allow:

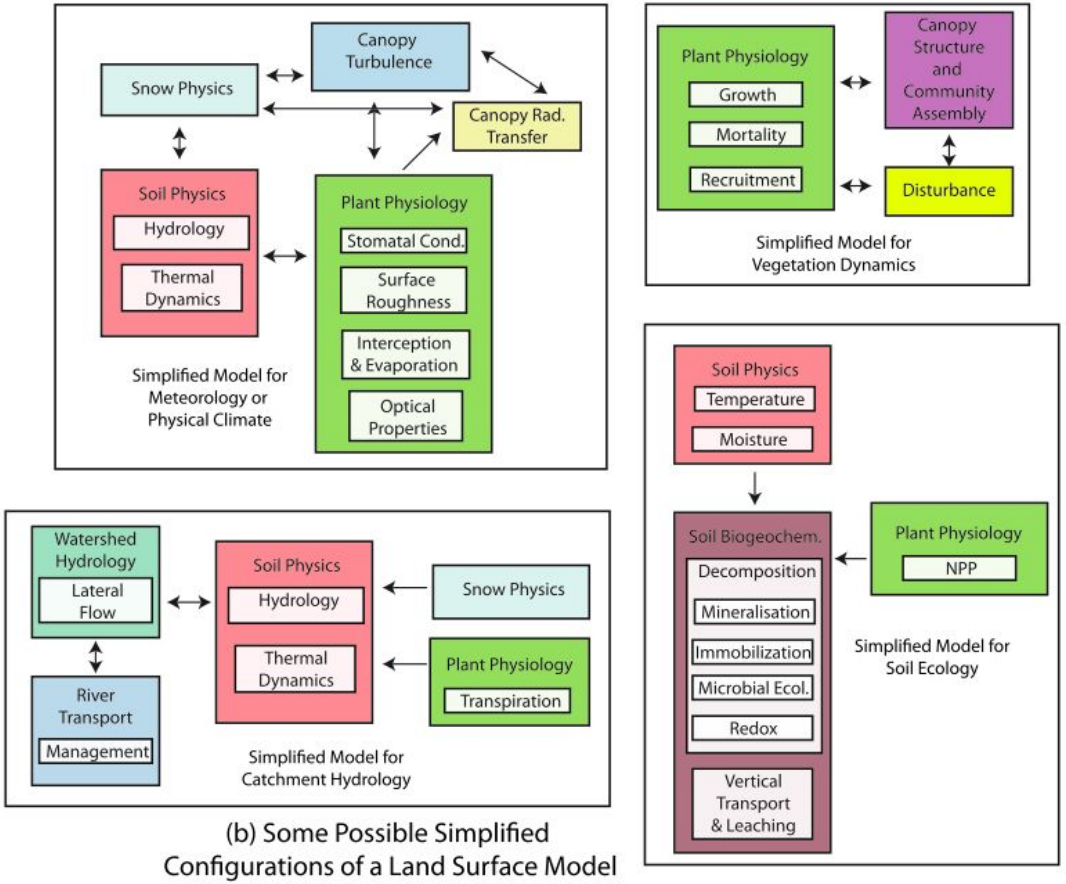
**-Disentangling** of the impact of different parts of the system on fully coupled model behaviour.

**AND**

**-Testing and use of FATES sub-models** (radiation transfer, canopy structure, vegetation competition, etc.) where **specific parts of the system can be proscribed.**

e.g. Applications in hydrology, biogeochemistry, land use, biogeophysics

# “Modular Complexity” as a strategy to manage process proliferation

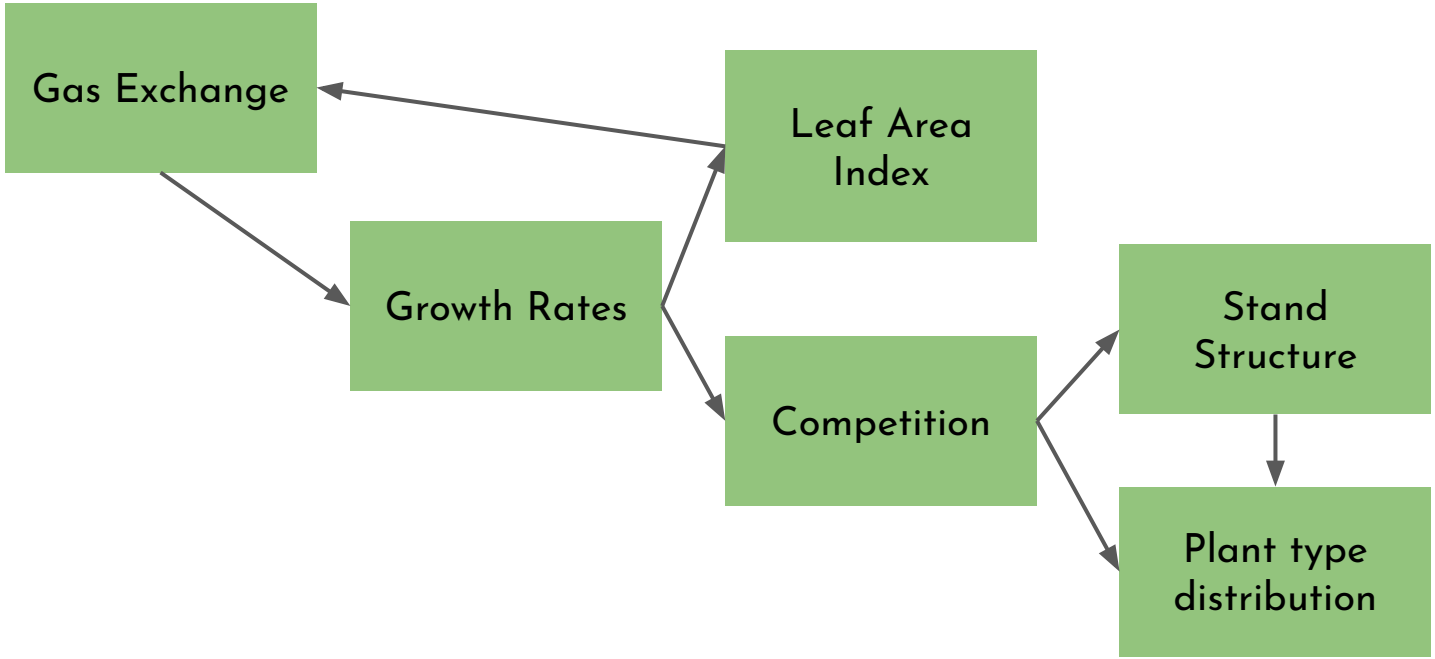



(b) Some Possible Simplified Configurations of a Land Surface Model

Fisher and Koven. JAMES 2020

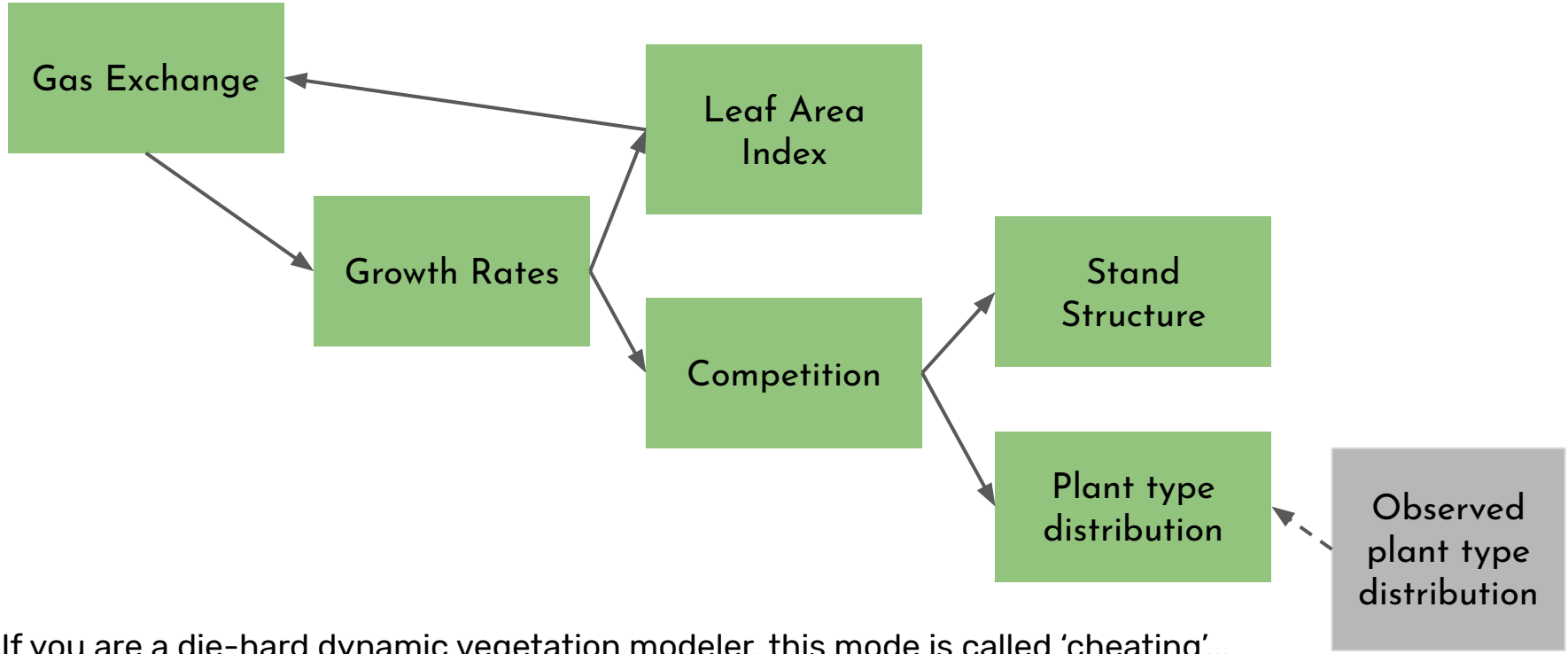
FATES MODULAR COMPLEXITY APPROACH

**FULL COMPLEXITY MODE**



FATES MODULAR COMPLEXITY APPROACH

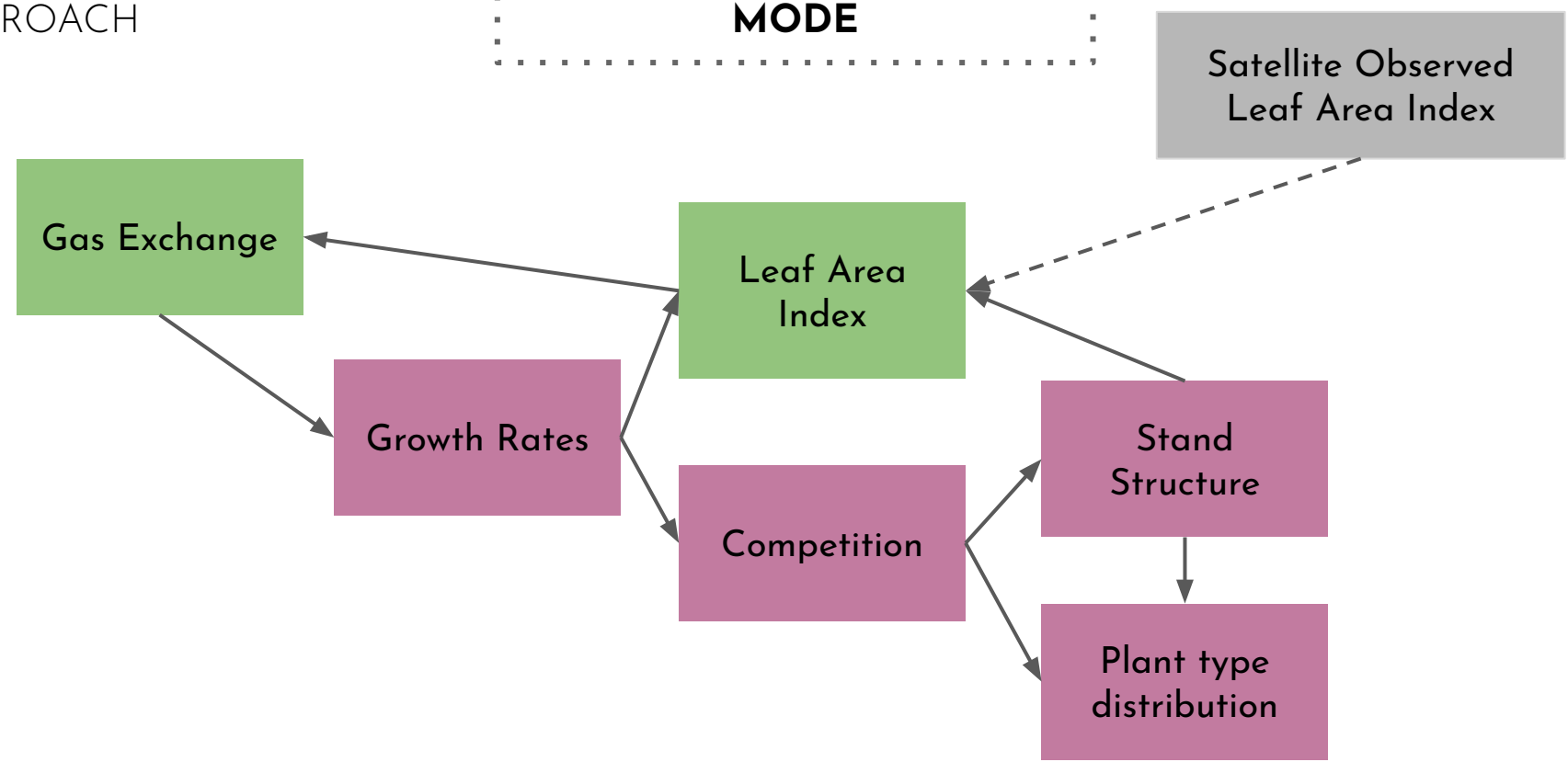
**FIXED BIOGEOGRAPHY MODE**




n.b. If you are a die-hard dynamic vegetation modeler, this mode is called 'cheating'...

FATES MODULAR COMPLEXITY APPROACH

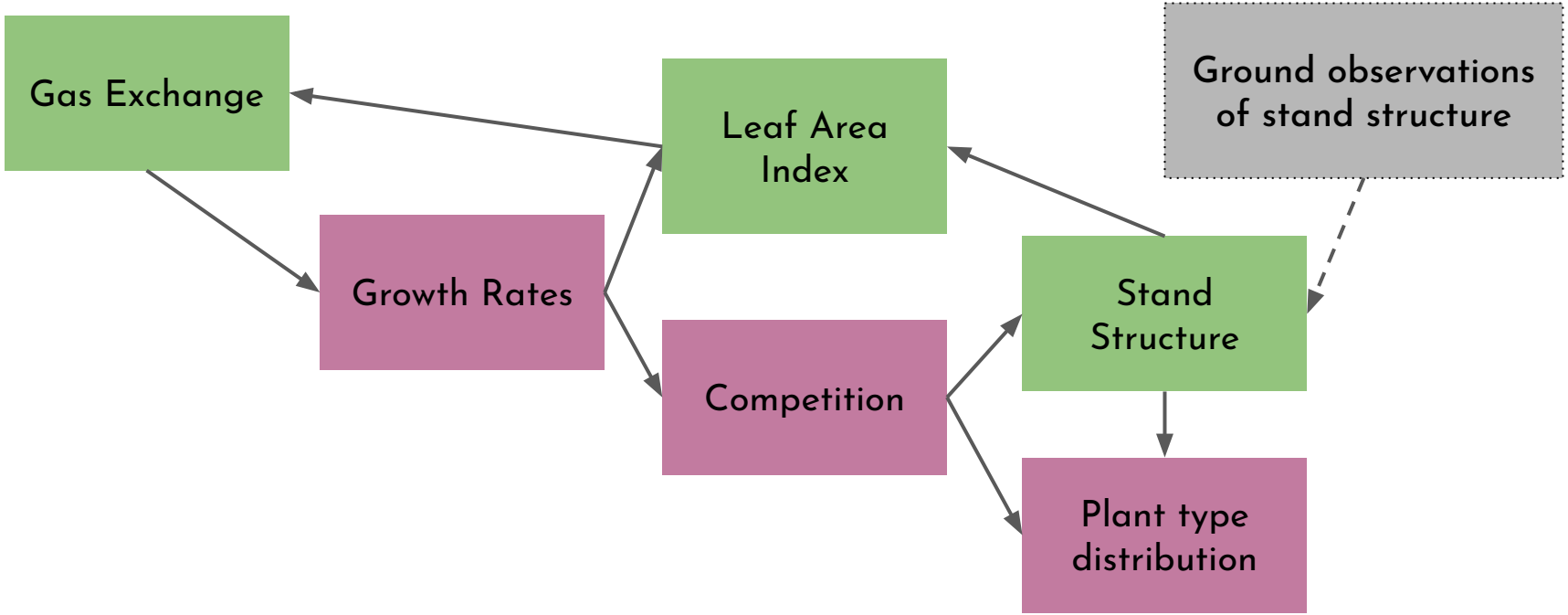
**SATELLITE PHENOLOGY MODE**




This mode might be used to test skill of gas exchange algorithms, or for short-term prediction applications.

FATES MODULAR COMPLEXITY APPROACH

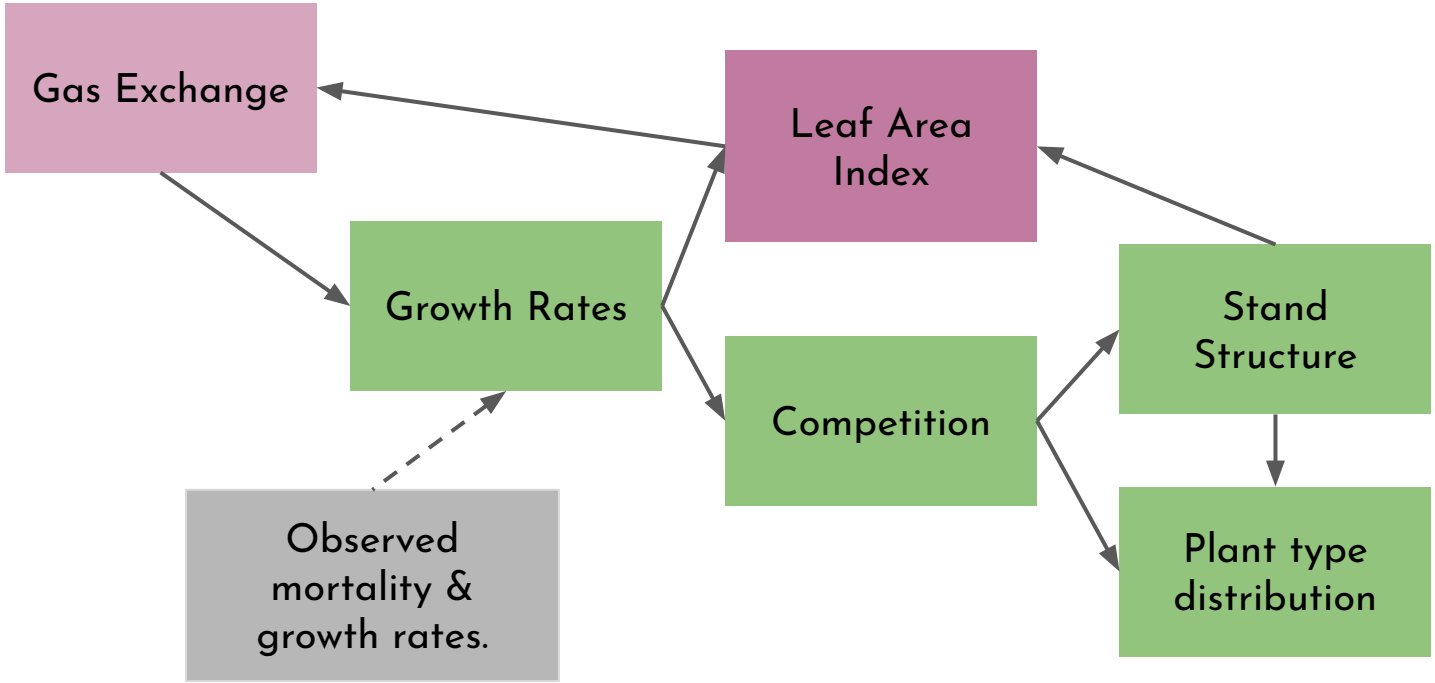
**STATIC STAND STRUCTURE MODE**




This mode is also used to test gas exchange (& e.g. hydraulics) but with more data on canopy composition

FATES MODULAR COMPLEXITY APPROACH

**PROSCRIBED PHYSIOLOGY MODE**

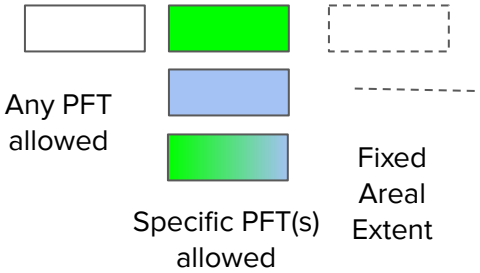



This mode can be used to test competition & community assembly processes. (Needham et al. in press)

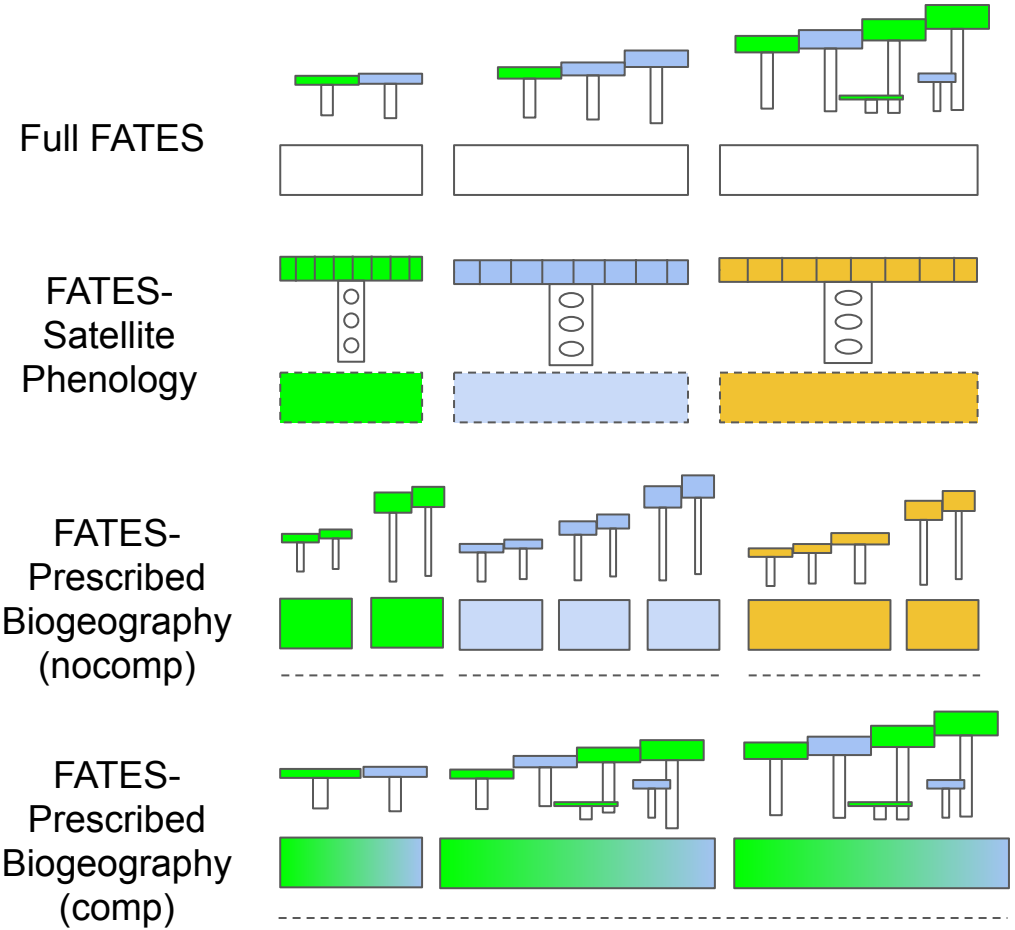
# FATES patch/cohort structure

## Key

**Patch types**




**Cohort types**


(Slide modified from concept by Charlie Koven)

# Processes on and off in each mode

(Default FATES)

| Process | RTM | Gas Exchange | Allocation | Canopy Structure | Litter & seeds | Recruits | PFTs share patches | Recruits everywhere? |
|---|---|---|---|---|---|---|---|---|
| **NOFixedBG_COMP** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |
| **FixedBG_COMP** | **Y** | ***Y*** | **Y** | **Y** | **Y** | **Y** | **Y** | **N** |
| **FixedBG_NOCOMP** | **Y** | ***Y*** | **Y** | **Y** | **Y** | **Y** | **N** | **N** |
| **NoFixedBG_NOCOMP** | **Y** | ***Y*** | **Y** | **Y** | **Y** | **Y** | **N** | **N** |

FATES modes discussed in the following slides.

*n.b. That fire and plant hydraulics can already be turned on/off already with use_fates_spitfire and use_fates_plant_hydro

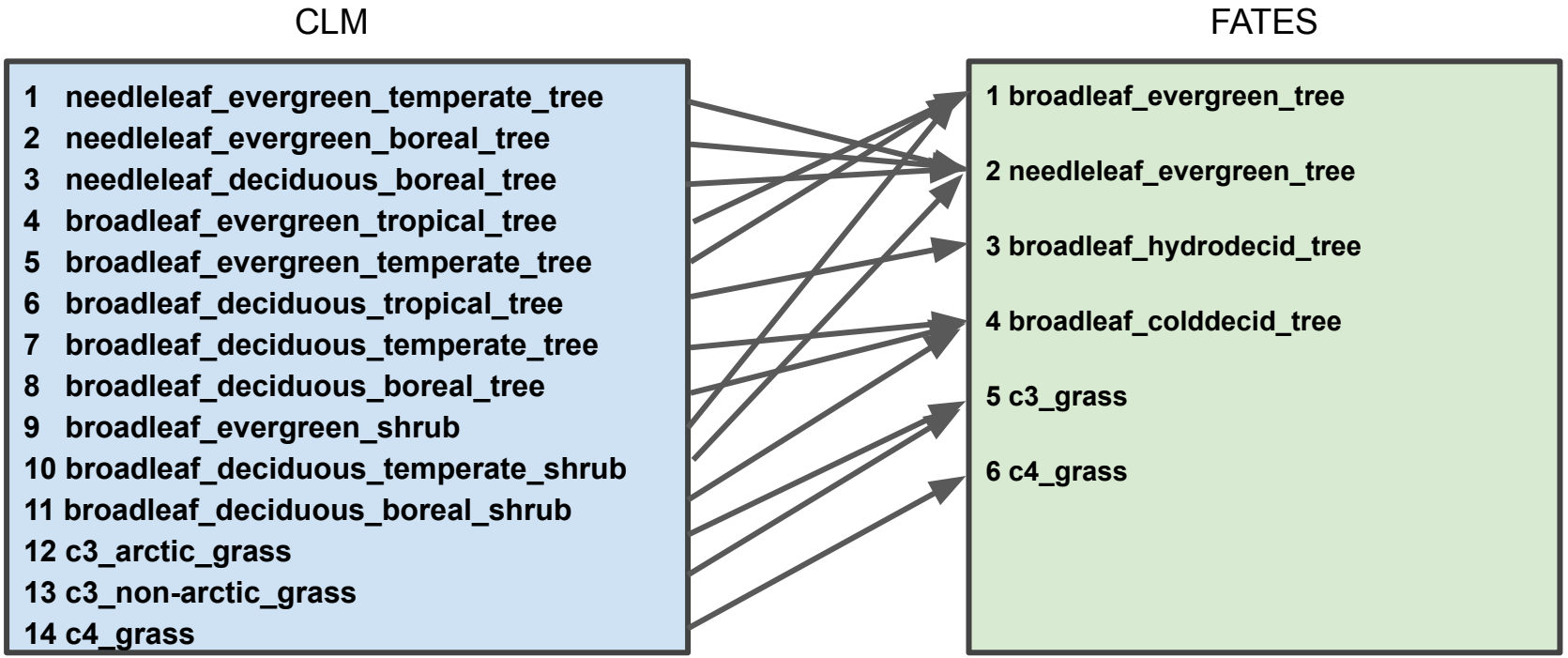
# Processes on and off in each mode

(Default FATES)

| Process | RTM | Gas Exchange | Allocation | Canopy Structure | Litter & seeds | Recruits | PFTs share patches | Recruits everywhere? |
|---|---|---|---|---|---|---|---|---|
| **NOFixedBG_COMP** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |
| **FixedBG_COMP** | **Y** | ***Y*** | **Y** | **Y** | **Y** | **Y** | **Y** | **N** |
| **FixedBG_NOCOMP** | **Y** | ***Y*** | **Y** | **Y** | **Y** | **Y** | **N** | **N** |
| **NoFixedBG_NOCOMP** | **Y** | ***Y*** | **Y** | **Y** | **Y** | **Y** | **N** | **N** |
| **SP Mode** | **Y** | ***Y*** | **N** | **N** | **N** | **N** | **N** | **N** |
| **SST Mode** | **Y** | ***Y*** | **N** | **N** | **N** | **N** | **Y** | **N** |
| **PPM Mode** | **N** | **N** | **Y** | **Y** | **Y** | **Y** | **Y** | **Y** |

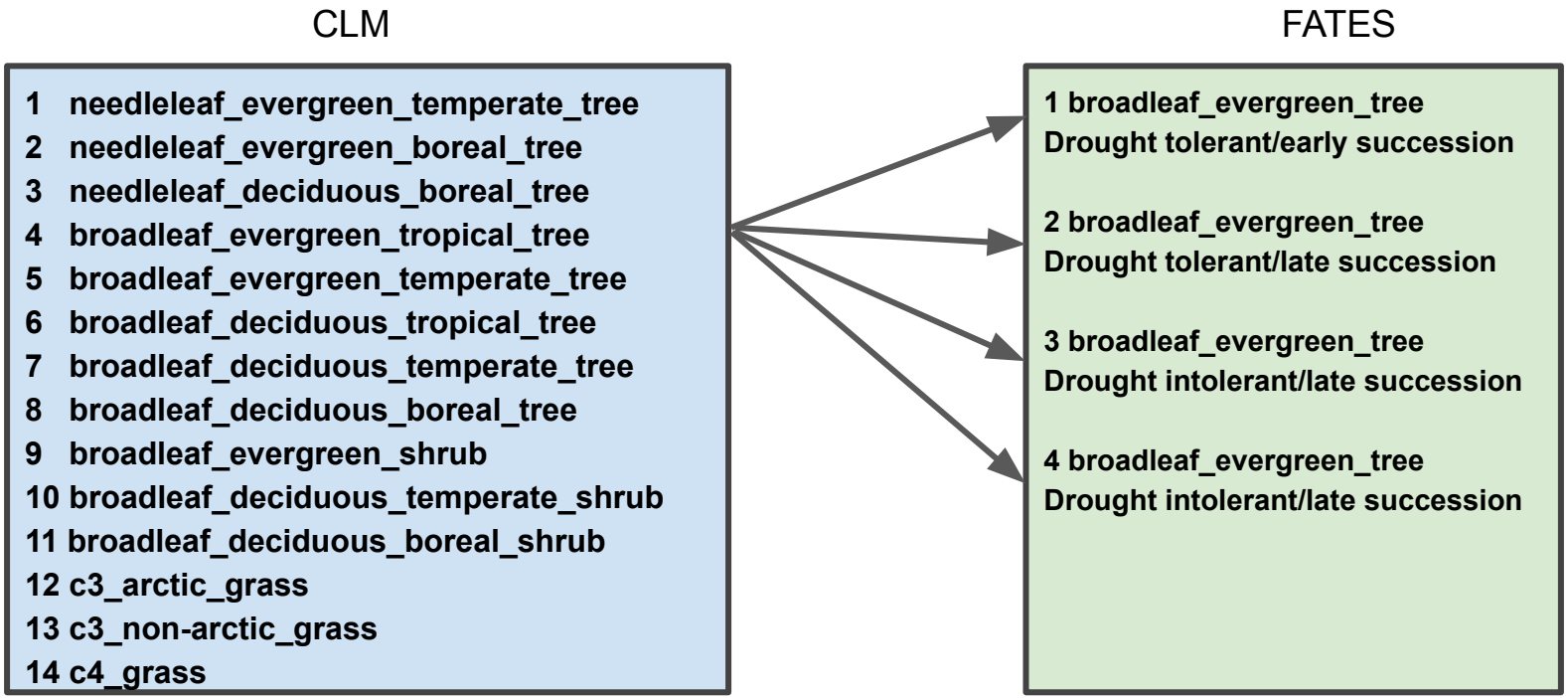
*n.b. That fire and plant hydraulics can already be turned on/off already with use_fates_spitfire and use_fates_plant_hydro

# New Host Land Model - FATES PFT mapping capability




#FATES PFTs < #HLM PFTs: Aggregate HLM PFTs into groups.

# New Host Land Model - FATES PFT mapping capability




#FATES PFTs > #HLM PFTs: Impose a diversity of FATES PFTs.

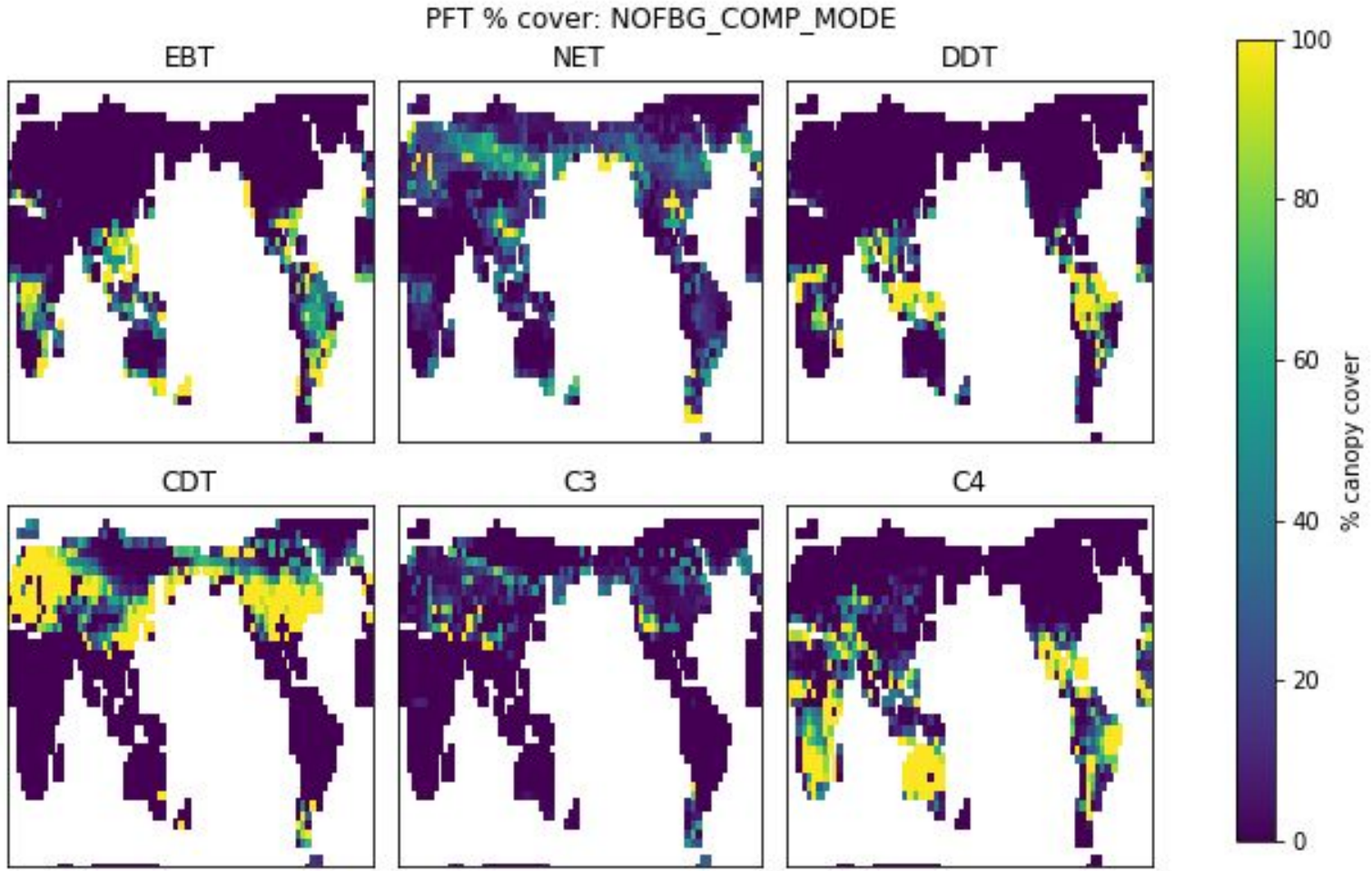
# A note on the setup of the runs shown here

4x5 simulations

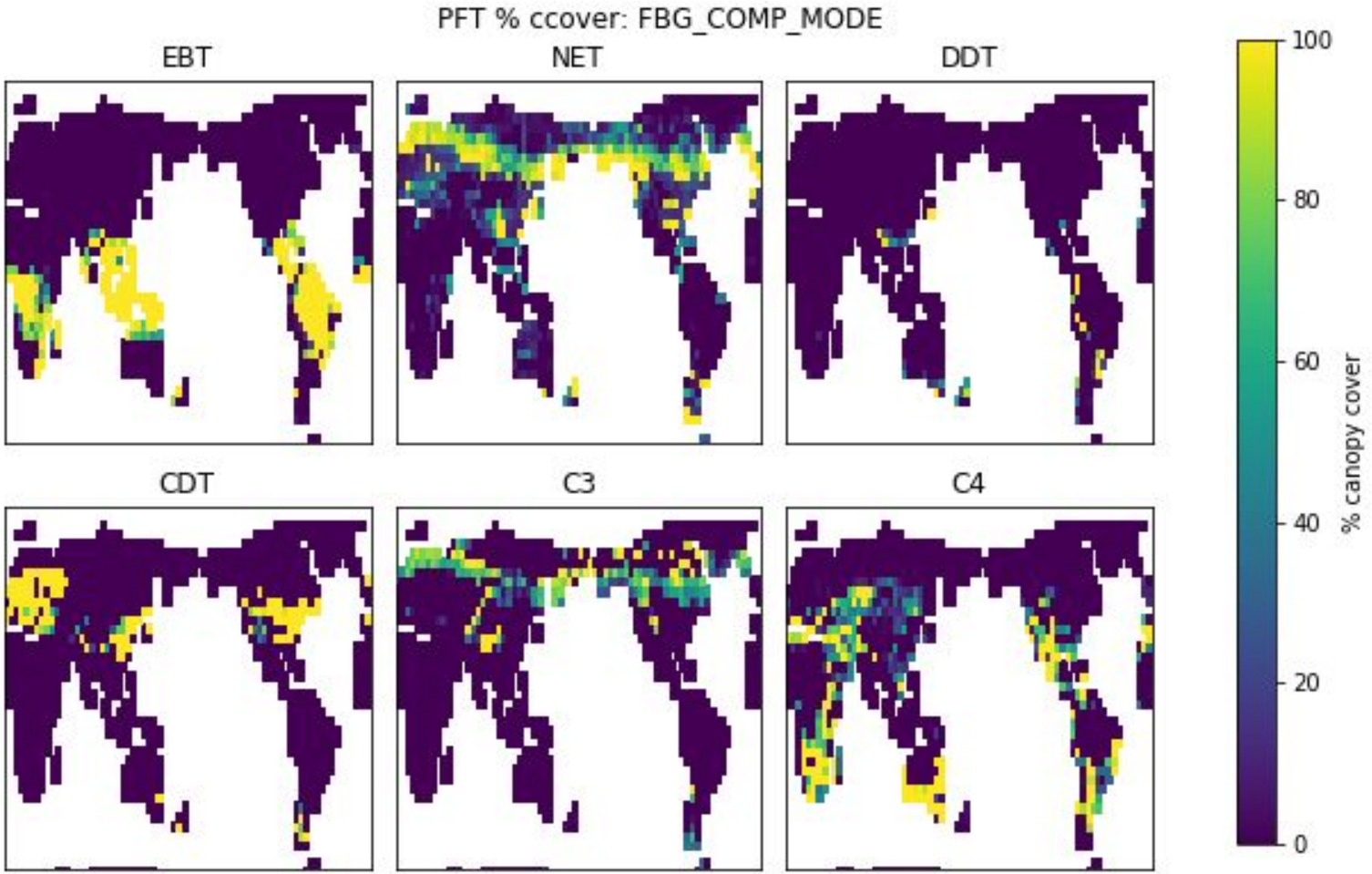
6 Plant Functional Types, as above

50 years spin up

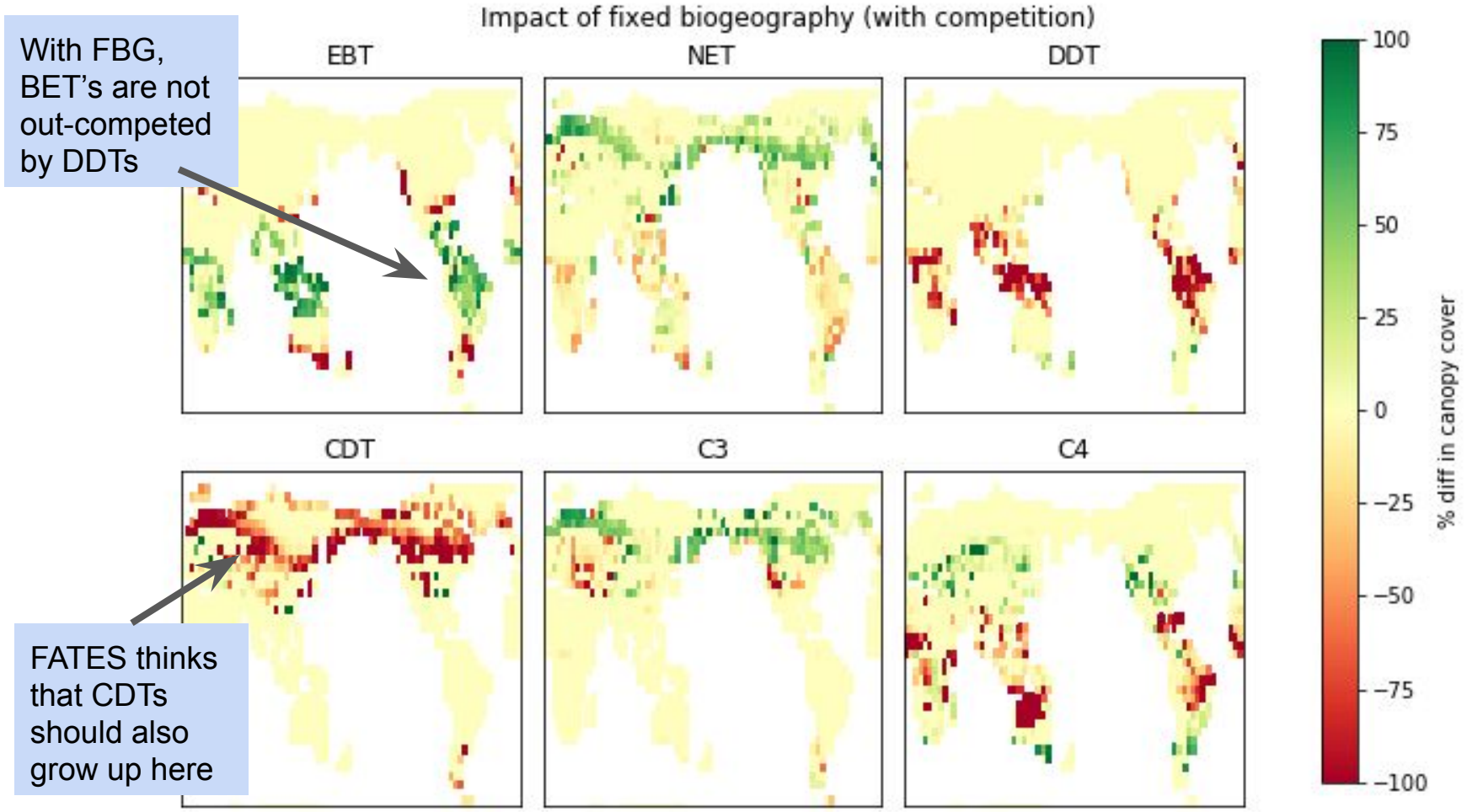
| SETUP | Fixed Biogeography | Competition |
|---|---|---|
| NOFBG_COMP | NO | YES |
| FBG_COMP | YES | YES |
| NOFBG_NOCOMP | NO | NO |
| FBG_NOCOMP | YES | NO |



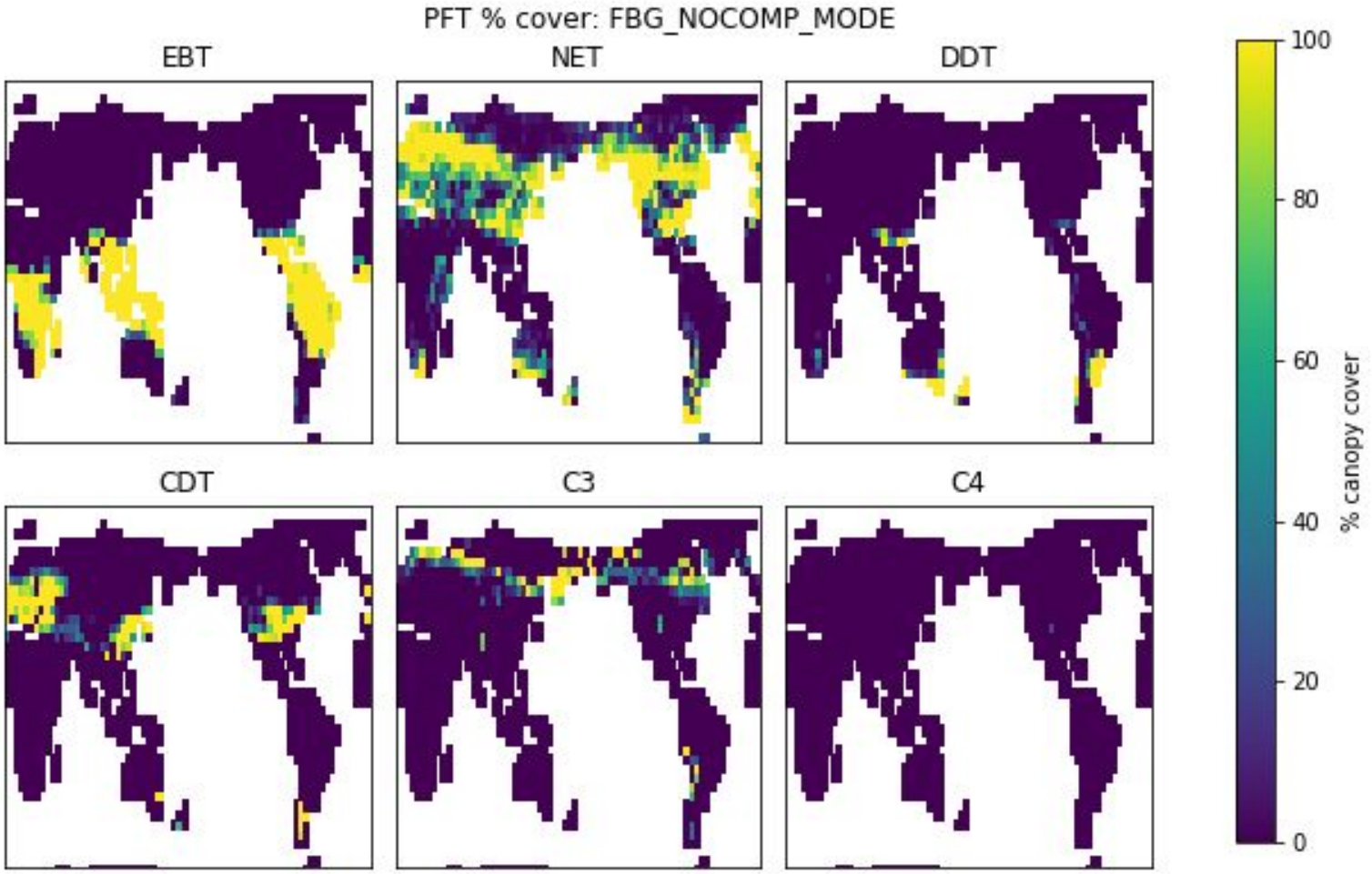

THIS IS THE **DEFAULT**, FULL-COMPLEXITY MODE FOR RUNNING FATES.




**ADD FIXED BIOGEOGRAPHY MODE**

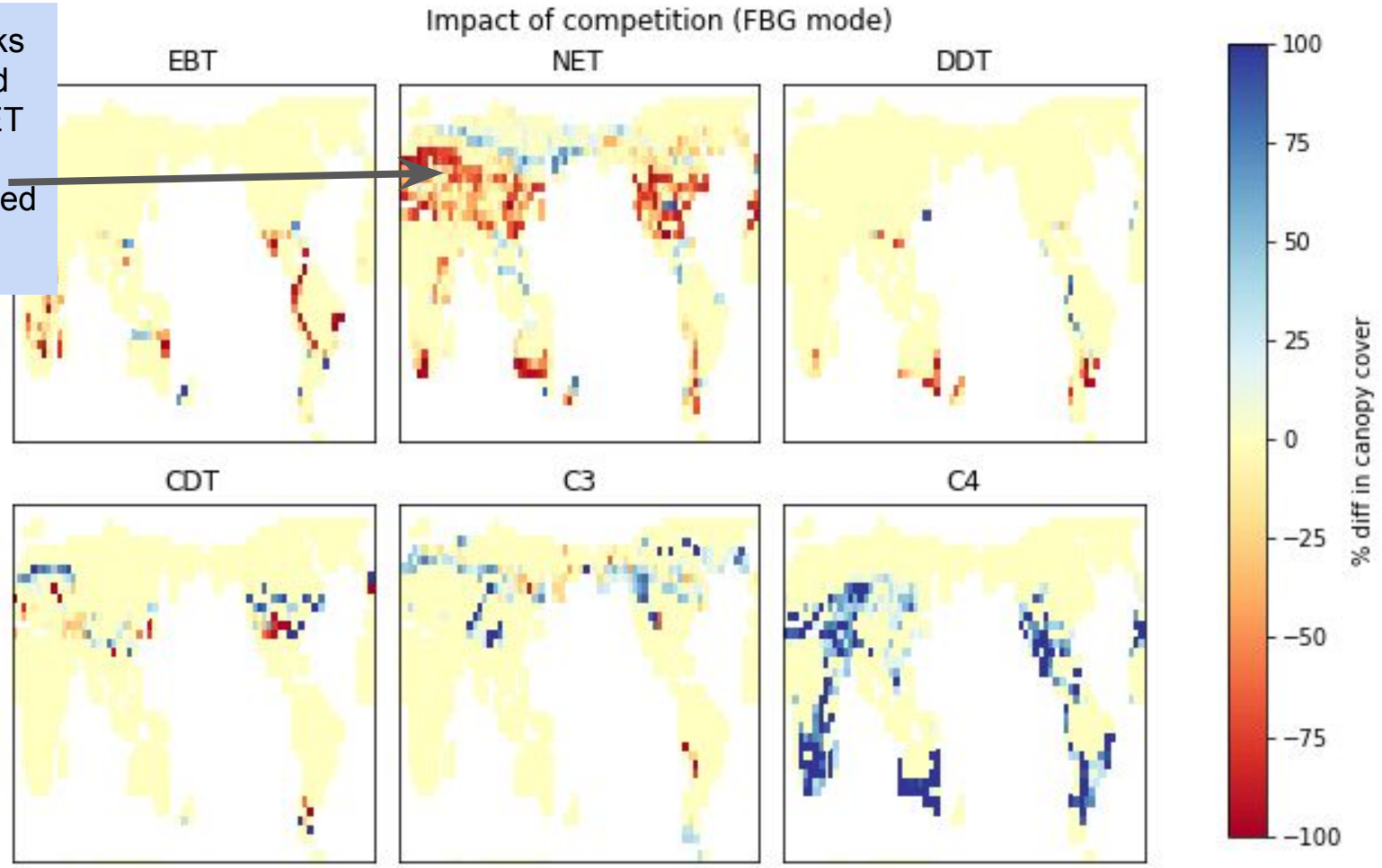


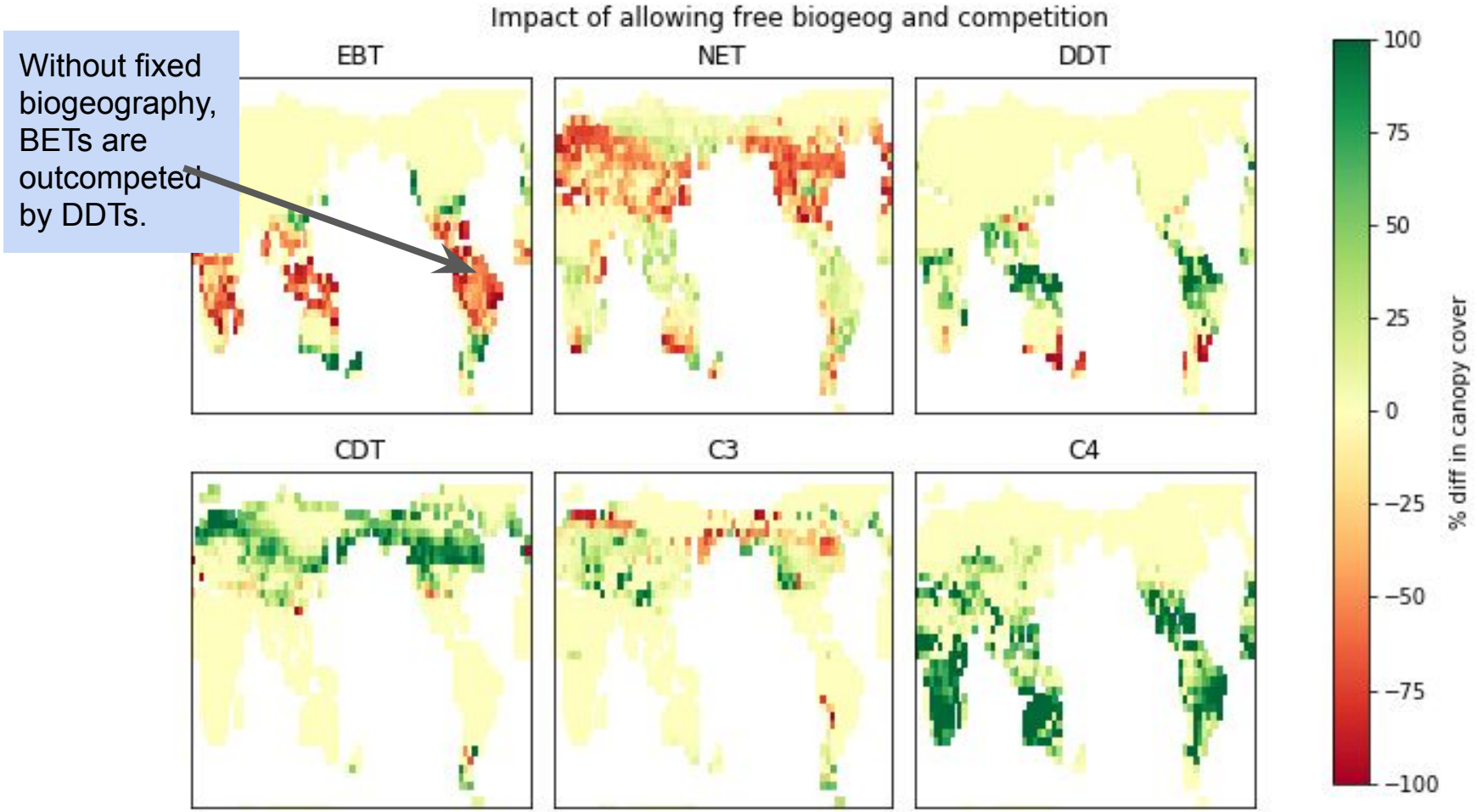

How does fixing biogeography change PFT distribution compared to full-FATES.




**REMOVE PFT COMPETITION**

FATES thinks there should be more NET at high lats than observed






full-FATES vs. fixed, no comp FATES. This identifies biases caused by dynamic biogeography

# Status (http://github/NGEET/FATES)

- Fixed Biogeography is now on the FATES trunk (PR#612)
- ‘No competition’ mode and PFT mapping are on a branch

https://github.com/rosiealice/fates/tree/new_fates_nocomp

Caveats

1. ‘No competition’ mode right now only works with patch dynamics turned off
2. We will need to resolve interactions with land use developments

# Outlook

Our hope is that this effort will

a) Accelerate progress toward identifying and addressing model biases (parametric & structural)

b) Facilitate migration of CTSM developments into FATES context via use of models with fewer moving parts where appropriate.

c) Ultimately, generate a flexible land surface model with ‘modular complexity’ that can help us out of the marshes…

Please send us feedback on this effort (e.g. ideas for other modes…)

(rosieafisher@gmail.com)