In Greek mythology, the Moirai—often known in English as the Fates—were the white-robed incarnations of destiny. Their number became fixed at three: Clotho (spinner), Lechesis (allotter) and Atropos (unturnable). They controlled the metaphorical thread of life of every mortal from birth to death.
FATES: Functionally Assembled Terrestrial Ecosystem Simulator
FATES is derived from the CLM(Ecosystem Demography) Model

Fisher et al. Geoscientific Model Development 2015
FATES: modularized vegetation within a host land model

HLM

- hydrology
- energy balancing
- soil carbon
- soil biogeochemistry

everything else

FATES

- leaf sun fraction
- soil water state
- relative root water uptake
- air state
- canopy resistance
- Mean temp, water memory
- litter fluxes, area indices
- atm radiation
- albedo

btran

- photosynthesis / respiration
- dynamics (daily)
- canopy radiation
FATES subgrid structure
FATES aligns sites to CLM columns and linked-list patches to CLM vectorized patches for physiological calculations.
A stand-alone software module

Current layout

One code-set (CLM-FATES)
NGEE-T keeps a clone of CLM-FATES on github (rapid FATES update cycle, delayed CLM update cycle)
NCAR keeps origin on SVN (rapid CLM update cycle, delayed FATES)

Future layout
(In time for CESM2 public release)

CLM Software System

SVN pointers to pull

FATES Submodule (git/github)
FATES only code

Git submodule

ALM Software System
The ‘Perfect Plasticity Approximation’ (PPA)

- Tree canopies are ‘perfectly plastic’ and fill in all the gaps.
- Forest canopy splits into distinct layers.
  - Canopy : 100% incoming light on top leaf surface
  - Under-story : All have the same reduced light environment

Purves et al. 2007
PPA model means that there are two distinct environments in FATES
Also, two conserved quantities: Carbon and Individuals

Example of dynamics that occur in FATES
Parameter Sensitivity Analyses

Massoud et al, in review
Steps underway to tame FATES: develop "lower-complexity configurations"

- **Seed mixing**: allow PFTs to seed each other to prevent competitive exclusion
- **Static Stand Structure**: allow physiology but decouple from growth and mortality
  - Allow phenologic dynamics to occur
  - Initialize either from restart or from inventory data
- **FATES-SP**: Leverage SP infrastructure to specify leaf phenology, thus cutting all feedback loops as in big-leaf CLM
Model Testbeds and PEcAn Framework

What is a testbed?

Testbeds developed to date

- BCI, Manaus
- Under development
  - Puerto Rico, Tanguru
  - Site scale, QA/QC'd model drivers, soil.
  - Benchmarks from site (demography, what else?)

CLM(FATES) integrated into PEcAn by Mike Dietze
Some FATES Mechanistic Developments and Analyses under way

• Brad Christoffersen: FATES-Hydrodynamics
• Jackie Shuman: Tropical fire dynamics
• Yi Xu: Logging and secondary forest dynamics
• Jennifer Holm: Extratropical PFT dynamics
• Various NGEE-Tropics members:
  – Canopy Radiation, Shade tolerance, Allocation strategies, trait filtering across horizontal moisture gradients, development of early-late successional PFTs
PFT competition analysis
Trait Filtering output

Too much competitive exclusion! (in this setup)

Year 5
Too much competitive exclusion! (in this setup)

Year 30
-PPA means that there is **only** a benefit to growing taller after the canopy is closed…

-R* type dynamics pull soil moisture down to levels lethal to all but the most tolerant elsewhere.

Purves et al. 2007
Summary

• FATES interface and FATES v1 will be frozen for CLM5.
• FATES refinement will continue post-CESM2 release.
• We welcome FATES-based developments and parameter investigations.
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