Plans for LULCC in FATES, plus some other steps on the path towards CLM6-FATES.

C. Koven, R. Fisher, R. Knox, M. Huang, Y. Xu, J. Shuman, and many others
Useful Resources:

FATES Github PAGE: https://github.com/NGEET/fates


FAQ: “When will FATES run globally?”

Short answer: FATES already runs globally.

Longer Answer: While FATES does already run globally, there are a few things we need to get working in order to do CMIP, GCP/Trendy, or similar types of global change experiments. Foremost among these are the ability to ingest and work with global LULCC datasets.
Why LULCC in FATES should be different (and better) than in big-leaf CLM
How does this translate to the full CLM subgrid hierarchy?
What do we want the LULCC in FATES to look like ultimately?
Current Status of LULCC in FATES: Logging module

Maoyi Huang and Yi Xu (PNNL) have led the development of a preliminary logging module.

Allows specification of discrete event-based logging treatment, with the following parameters:

- Harvest frequency and date
- Harvest Intensity
- Minimum diameter of trees harvested
- PFT to be harvested
- Fraction of forest area killed by logging infrastructure
- Understory mortality rate in logged areas

Manuscript incl. comparison with data near Manaus, in prep
Structured land use representation in FATES

Original (no land use)
- FATES Patch n
- FATES Patch 3
- FATES Patch 2
- FATES Patch 1
- CLM or ELM Naturally Vegetated Column

Initial Land Use Model: Labeled Patches
- FATES Primary Patch n
- FATES Primary Patch 3
- FATES Primary Patch 2
- FATES Primary Patch 1
- FATES Secondary Patch n
- FATES Secondary Patch 3
- FATES Secondary Patch 2
- FATES Secondary Patch 1
- CLM or ELM Naturally Vegetated Column

Long-Term Goal: Multiscale heterogeneity
- FATES Primary Patch n
- FATES Primary Patch 3
- FATES Primary Patch 2
- FATES Primary Patch 1
- FATES Secondary Patch n
- FATES Secondary Patch 3
- FATES Secondary Patch 2
- FATES Secondary Patch 1
- CLM or ELM Naturally Vegetated Column
- CLM or ELM Secondary Vegetation Column
Collaborative meeting on path forwards for FATES in CESM & E3SM


- Articulated strategy shared across projects to get land use working

- The Plan
  - Follow the earlier schematic, with drivers for land use being as close to the LUH2 datasets as possible, and CLM and ELM passing this driver info to FATES which drives the LULCC dynamics
Initial testing of FATES output to track secondary forest area:

- Annual Logging event
- 15% of all trees with DBH > 50cm harvested
- All crown area of harvested trees becomes secondary forest
- Currently the surviving trees remain in primary forest — still need to update disturbance routines so that unharvested trees adjacent to the logged trees also become secondary forest
A proposed LULCC Information Flow

CLM5

RCP Land Units for Year N

<table>
<thead>
<tr>
<th>Primary Forest</th>
<th>Primary Non Forest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second Non For</td>
<td>Crops C3/C4</td>
</tr>
<tr>
<td></td>
<td>Irrig/Rainfed</td>
</tr>
<tr>
<td></td>
<td>Annual Fertilizer</td>
</tr>
<tr>
<td>Second Forest</td>
<td>Pasture</td>
</tr>
<tr>
<td></td>
<td>Rangeland</td>
</tr>
</tbody>
</table>

Describe Land Units in CLM5 PFT/CFTs

<table>
<thead>
<tr>
<th>PF PFTs</th>
<th>PNF PFTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNF PFTs</td>
<td>Crop CFTs</td>
</tr>
<tr>
<td></td>
<td>Irrig/Rainfed</td>
</tr>
<tr>
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<td>Annual Fertilizer</td>
</tr>
<tr>
<td>SF PFTs</td>
<td>Pasture PFTs</td>
</tr>
<tr>
<td></td>
<td>Grass PFTs</td>
</tr>
<tr>
<td></td>
<td>Rangeland PFTs</td>
</tr>
<tr>
<td></td>
<td>Urban</td>
</tr>
</tbody>
</table>

Annual Land Unit PFTs combined to give average grid cell PFTs for Year N

CLM5 Tech Note
A proposed LULCC Information Flow

CLM-FATES

LUH2 defines FATES primary/secondary land transitions directly

Forest/non-forest allowed to emerge from PFT competition

Crops / Urban defined as before

Pasture / Rangeland defined as FATES LU type and given management treatments
Steps towards a FATES-LULCC

1. Directly **read harvest time-series** (either in mass or area), pass to FATES, and use to drive FATES logging module, which generates primary/secondary forest fractions.

2. Diversify logging logic to **allow different types of harvest** (selective, clearcut, etc, with different parameters for different harvest types).

3. Directly **read full land use transition matrix**, pass to FATES, and use to drive FATES transitions. Keep all primary/secondary patches on same column.

4. **Separate primary and secondary FATES land** onto distinct columns, allowing primary columns to pass ecosystem structure to secondary columns during transitions.
What other things do we need? (to make FATES a versatile scientific tool)

- **Fixed vegetation mode:**
  - Read in a surface dataset and define multiple columns running FATES that allow only a subset of PFTs within each FATES column

- **PFT competition across key biome boundaries** (which?)

- **Crop model** (Software coexistence with FATES)

- **Nutrients** (in the works for NGEE-tropics Phase II)

- **Satellite Phenology** within FATES

- **Benchmarks:**
  - Standard ILAMB +
  - Biome boundary datasets
  - Canopy height distributions from remote sensing
  - ...

- **What else?**
Ongoing and planned FATES projects (non-exhaustive!)

- **NGEE-tropics (DoE/LBL-led tropics-focused project, Phase II proposal ongoing)**
  - Nutrient cycling, allocation
  - Fire, Gas Exchange, physiology testbeds
  - Tropical forest testbeds
  - Coexistence & trait filtering
  - FATES-Hydro testing & calibration
  - Tropical phenology
  - Radiation transfer

- **E3SM**
  - Land-use implementation (LUH2)
  - Global PFT calibrations

- **California/LBL proposals**
  - Parameters for Western US forests
  - Wildfire simulation & benchmarking
  - FATES x Hillslope model
  - Regeneration parameterization

- **University of Oslo (EMERALD, NorESM)**
  - High latitude PFTs & processes
  - Moss PFTs

- **LANL**
  - Insect dynamics, wetlands, fire-atmosphere interactions

- **University of Washington (Abby & Marlies)**
  - Competitive dynamics under high $\text{CO}_2$

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Biweekly FATES teleconferences starting soon
+ Thurs, 11am Pacific; 12am MDT, 8pm CET:
+ Sign up for alerts at:
Fates_model google group