

Updates on Land Use Change in FATES

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With input and help from many others: Rosie Fisher, Ryan Knox, Shijie Shu, Jackie Shuman, Peter Lawrence, Jennifer Holm, Adrianna Foster, Alan Di Vittorio, Jessie Needham, Marcos Longo, David Lawrence, Bill Sacks, Erik Kluzek

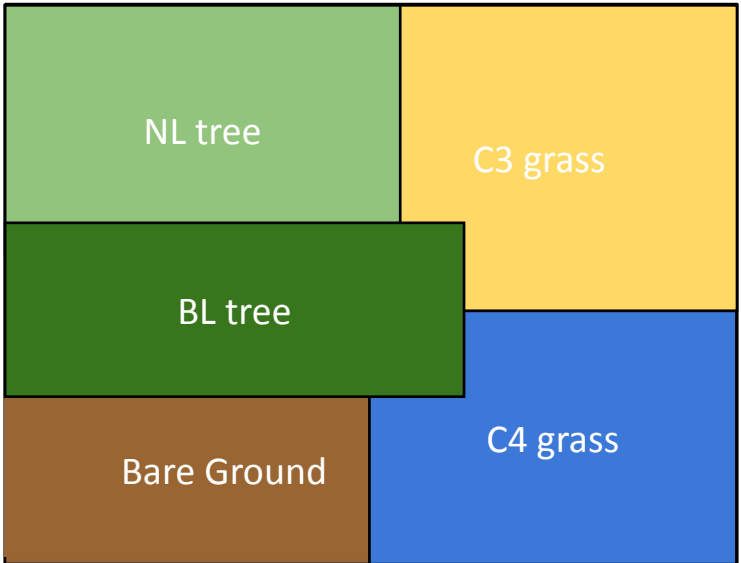


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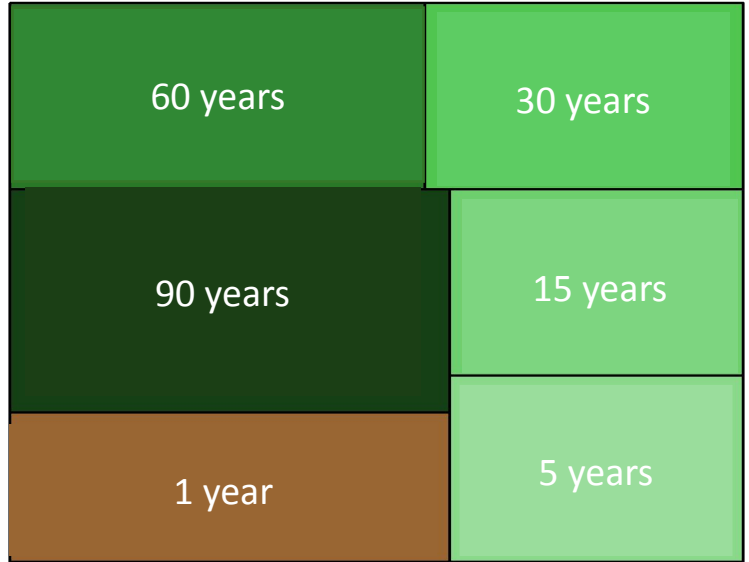


Vegetation structure: CLM/ELM vs ED models

Plant Functional Type tiling



Time-Since-Disturbance tiling

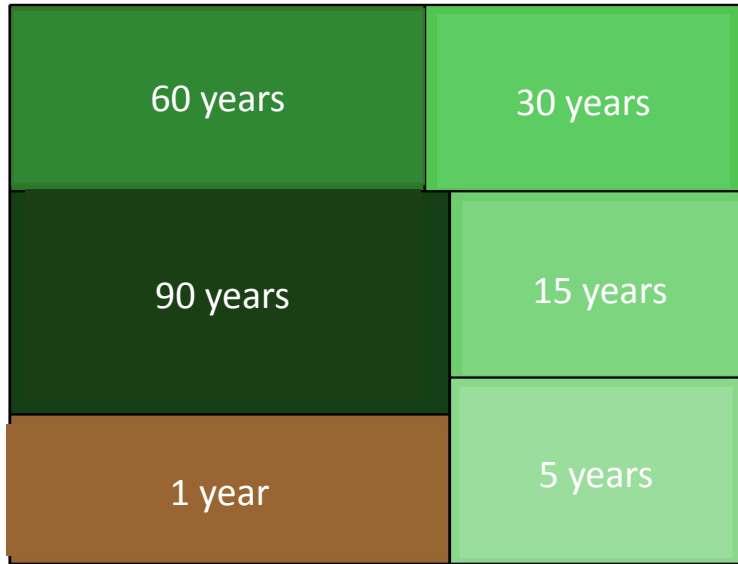


Slide courtesy Rosie Fisher: 2018 FATES tutorial

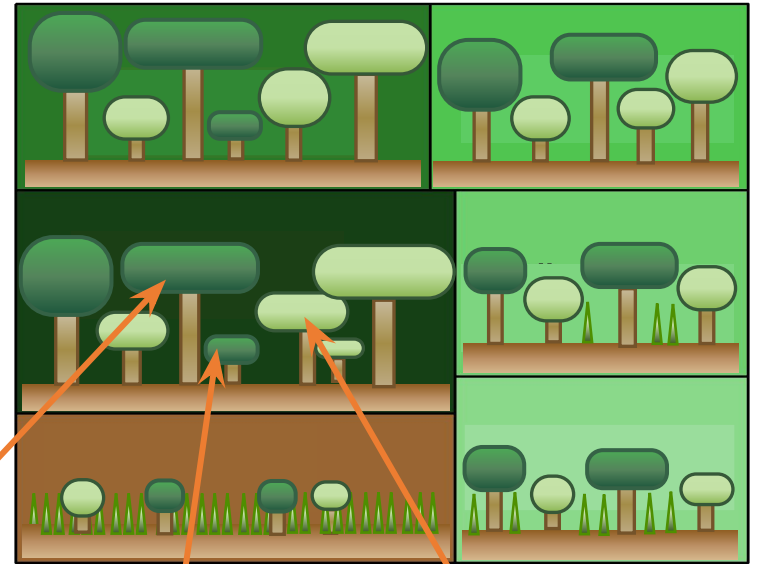
Vegetation structure in ED models

Each **time-since-disturbance** tile contains **cohorts** of plants, defined by **PFT** and **size**.

Time-Since-Disturbance tiling



Time-Since-Disturbance tiling



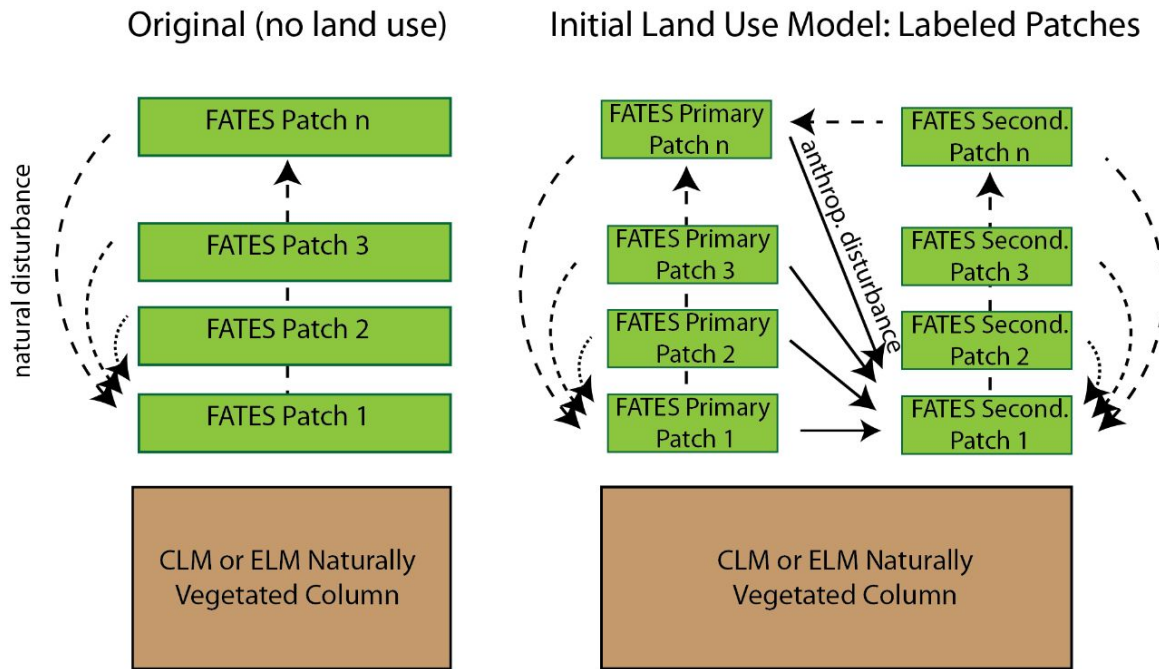
Cohort. PFT1. 10m

Cohort. PFT1. 2m

Cohort. PFT2. 4m

Slide: Rosie Fisher

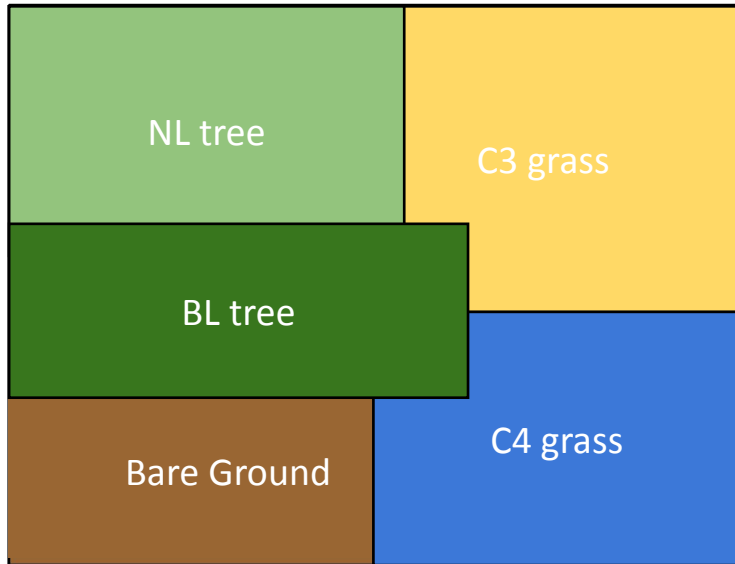
Disturbance tiling also directly allows land-use tiling (since much land use is disturbance)



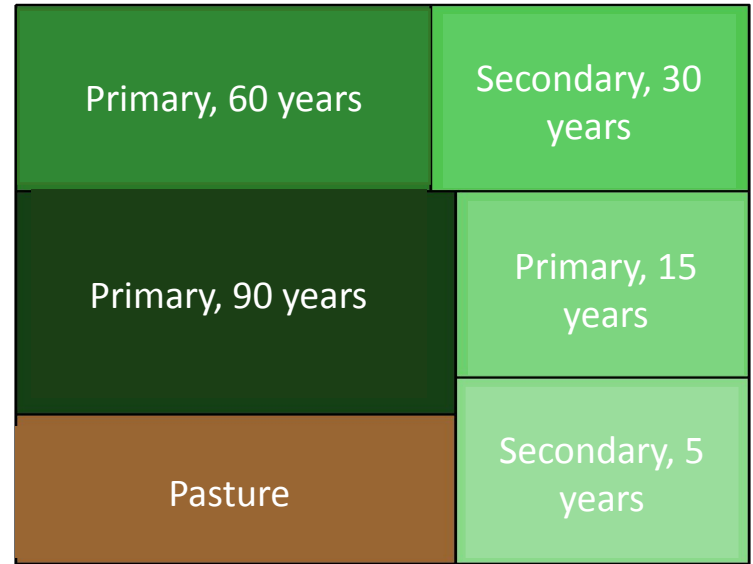
Current state of FATES main branch: 2 land use types (primary & secondary) driven by logging

Changing from big-leaf to demography model thus also means shifting from land cover to land use tiling

Land cover based tiling



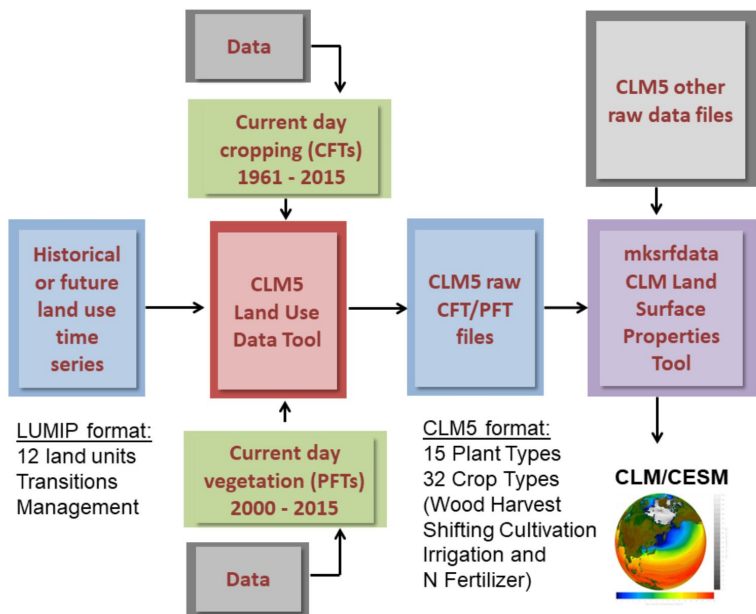
Land use based tiling



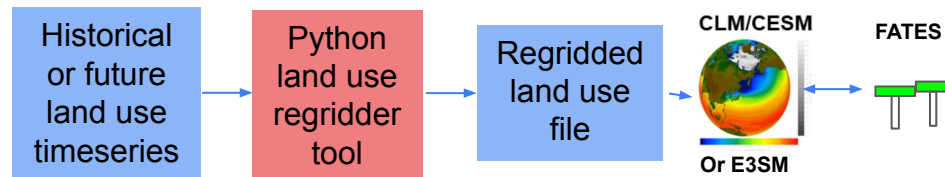
Putting full land use into FATES

Information flow: big-leaf vs FATES

CLM5 land use driver data



FATES land use driver data

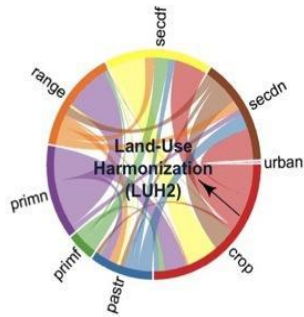


Peter Lawrence, (2022)
CLM5 Land Data Documentation

Incorporation of land use drivers into FATES

FATES land use types:
Primary, secondary, range, pasture, crop

LUH2 state and transition data



Donor Patch Type

Receiver Patch Type

Primary <i>treefall, fire</i>	<i>harvest</i>	<i>Land use change</i>	<i>Land use change</i>	<i>Land use change</i>
Secondary <i>harvest, treefall, fire</i>	<i>Land use change</i>	<i>Land use change</i>	<i>Land use change</i>	<i>Land use change</i>
Range <i>treefall, fire</i>	<i>Land use change</i>	Range <i>treefall, fire</i>	<i>Land use change</i>	<i>Land use change</i>
Pasture <i>fire</i>	<i>Land use change</i>	<i>Land use change</i>	Pasture <i>fire</i>	<i>Land use change</i>
Crop <i>fire</i>	<i>Land use change</i>	<i>Land use change</i>	<i>Land use change</i>	Crop <i>fire</i>

FATES now has four distinct disturbance types:

- *Treefall*
- *Fire*
- *Tree Harvest*
- *Land Use Change*

Clear vegetation during some land use transitions

Logic follows Ma et al (2020) <https://doi.org/10.5194/gmd-13-3203-2020>, default assumptions below:

		Receiver Patch Type			
		Primary	<i>harvest</i>	<i>Land use change</i>	<i>Land use change</i>
Donor Patch Type	Primary	Secondary harvest	<i>Land use change</i>	<i>Land use change</i>	<i>Land use change</i>
	Secondary	<i>Land use change</i>	Range	<i>Land use change</i>	<i>Land use change</i>
	Range	<i>Land use change</i>	<i>Land use change</i>	Pasture	<i>Land use change</i>
	Pasture	<i>Land use change</i>	<i>Land use change</i>	<i>Land use change</i>	Crop

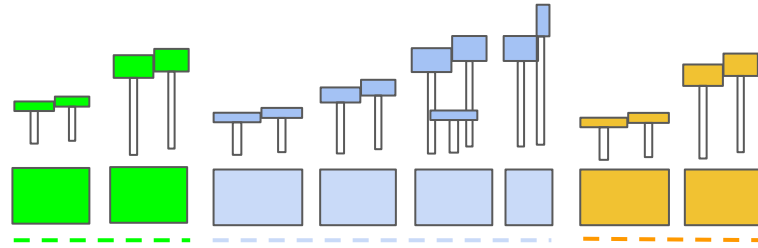
Dark grey: clear
Light grey: don't clear

What are the needed next steps for FATES Land Use Change (after v1)

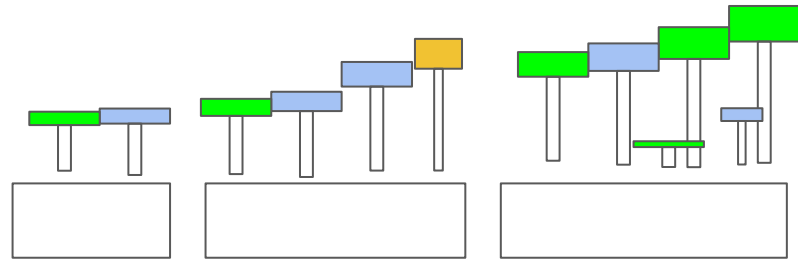
- Management on different land use patches
 - Grazing
 - E.g. after Rabin et al., 2018 (fixed rate of leaf consumption)
 - Fire
 - Either:
 1. Develop simplified fire climatology (again, e.g., after Rabin et al 2018)
 2. Make key fire parameters (e.g. # ignitions, intensity threshold) land-use-dependent
 - Simple parameterization for fugitive agricultural fires burning into primary/secondary
 - Landcover management on land use classes for prognostic landcover
 - E.g. max canopy cover for a given PFT on rangeland, etc
 - Only crops on croplands

But, wait, we can also make FATES behave like a model with prescribed landcover.
How do we handle land use then?

Prescribed Biogeography = True
nocomp = True
All PFTs given a fixed area to grow.
Growth & disturbance but no competition.



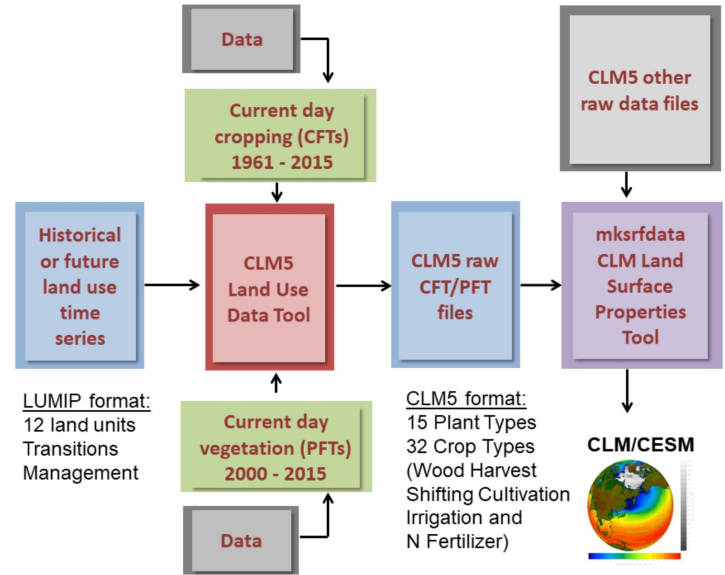
Full FATES
Growth, disturbance, and competition everywhere.



How do we make this also work with land use change?

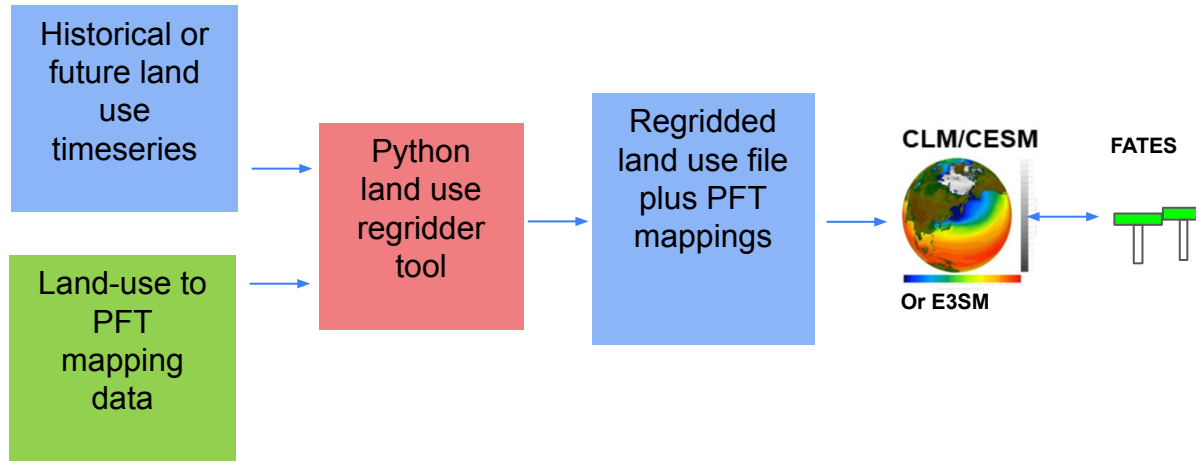
We have the data: PFT x land use mapping

- CLM5 files at https://gdex.ucar.edu/dataset/188b_oleson/file.html
 - CLM5_current_luhpasture_deg025.nc
 - CLM5_current_luhforest_deg025.nc
 - CLM5_current_luhoother_deg025.nc
 - CLM5_current_surf_deg025.nc
- LUH2 files: time-varying land use, time-independent forest/nonforest mapping
- Combine above to generate Land-use:PFT mappings
 - Primary & secondary = forest-/nonforest- weighted average of “forest” and “other” PFT mappings
 - Pasture = “pasture”
 - Range = “other”
 - Crop = crop PFT(s) only (in both nocomp and full-FATES configurations)
 - Hold bare-ground fraction fixed

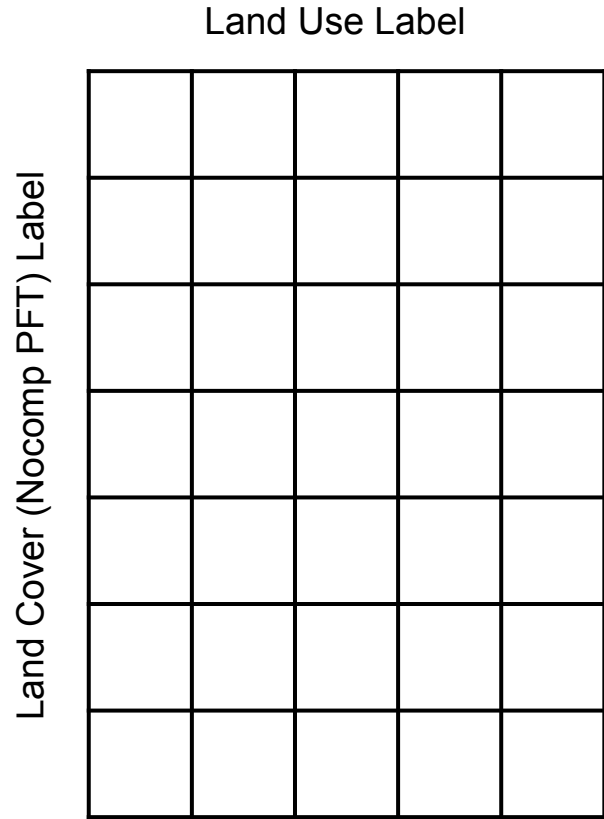


Peter Lawrence, (2022)
CLM5 Land Data
Documentation

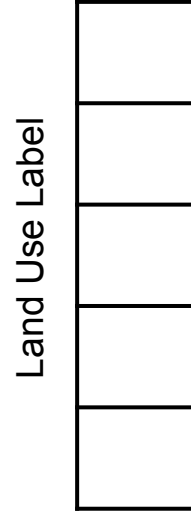
FATES-nocomp land use driver data (proposed)



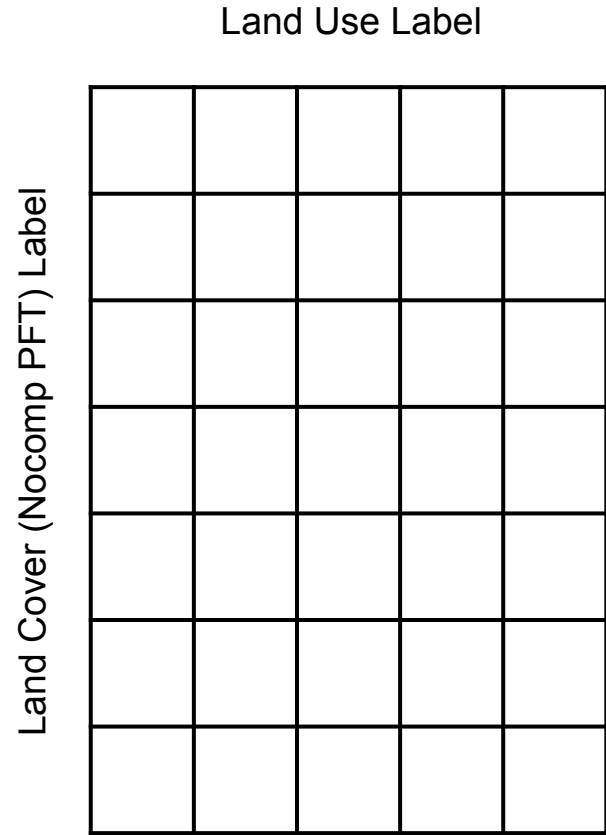
$$\text{Area}(x,y,L,P,t) = \text{State}(x,y,L,t) * \text{Mapping}(x,y,L,P)$$



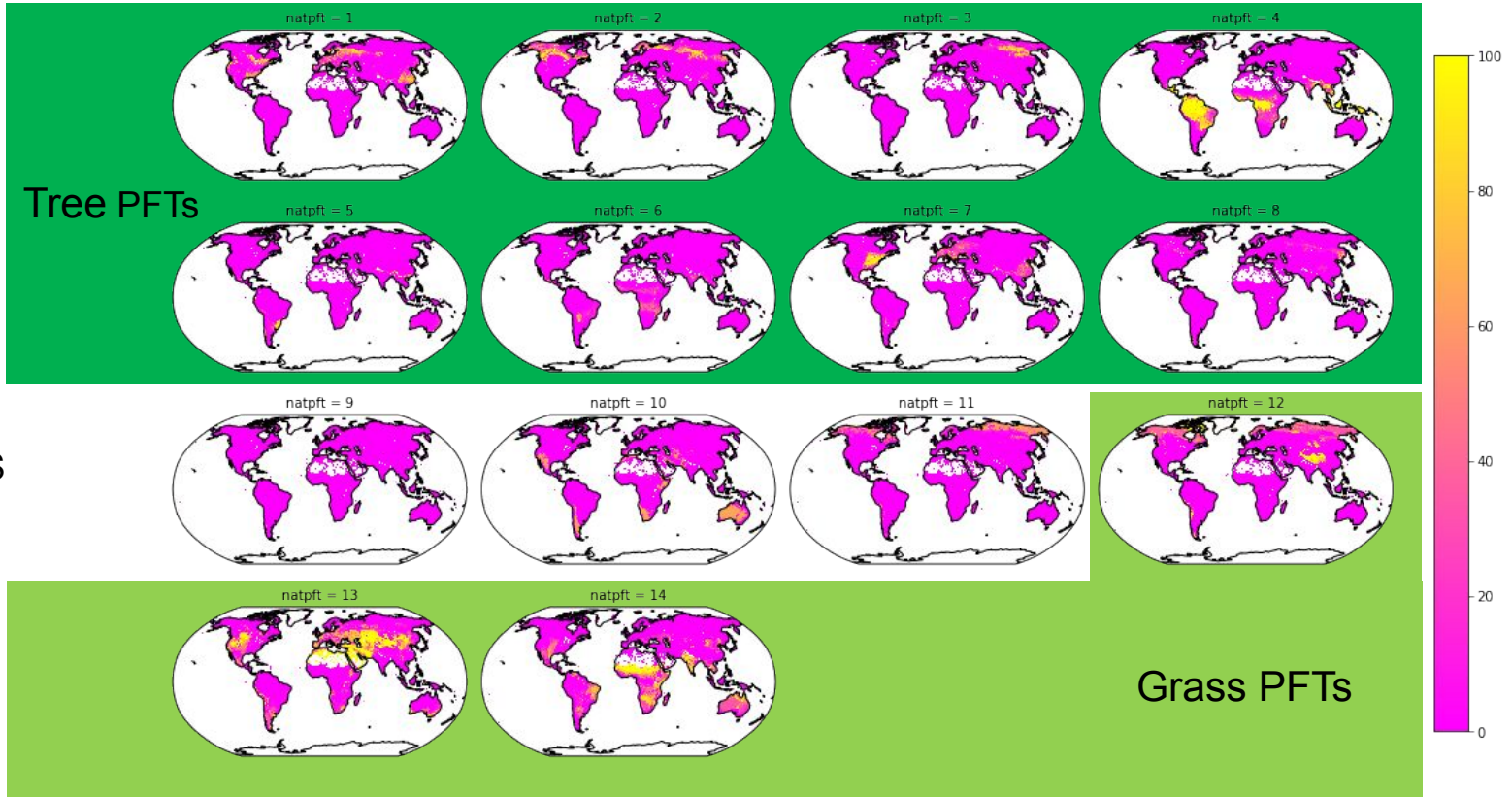
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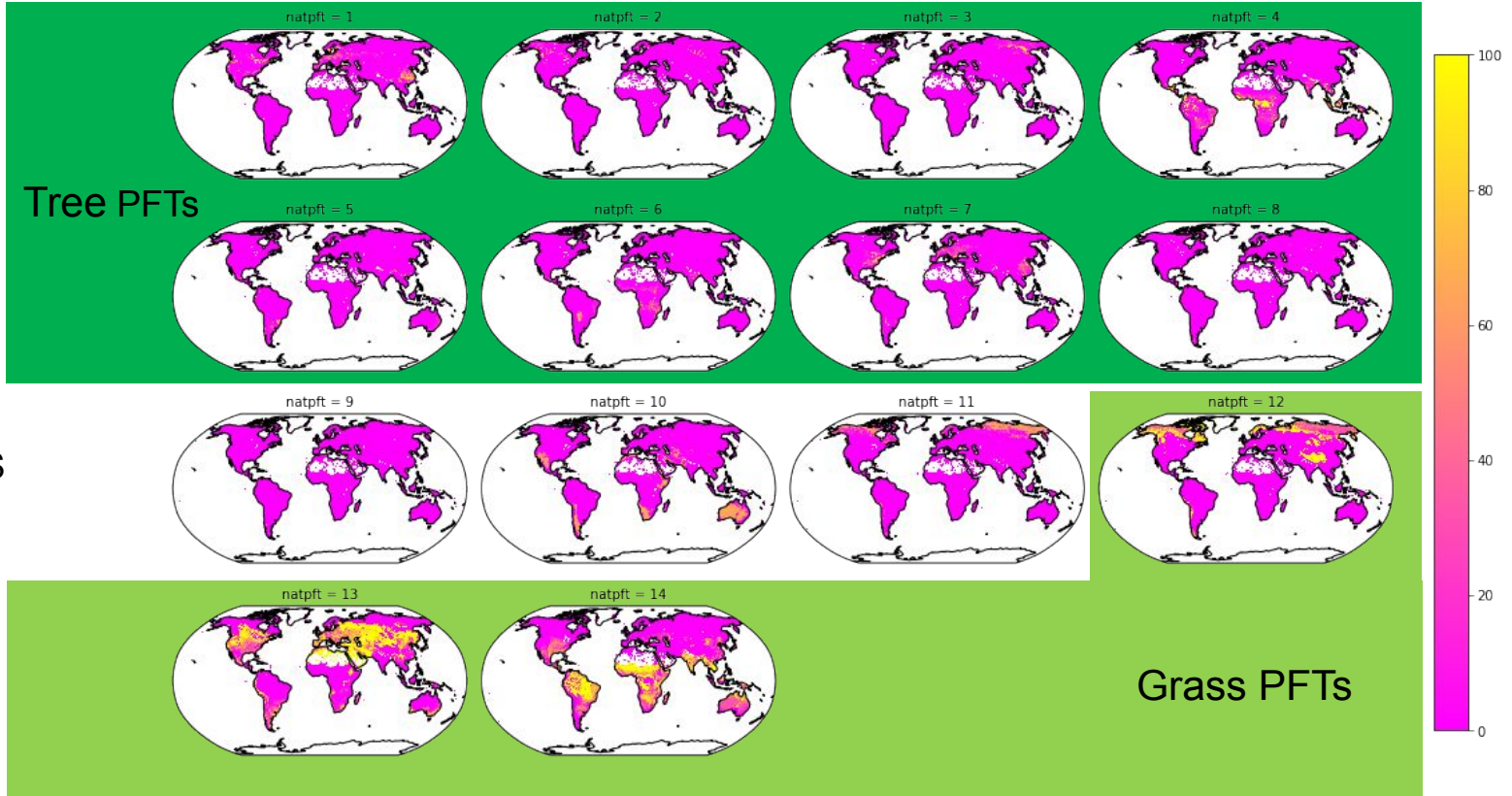


Primary and secondary lands PFT mapping



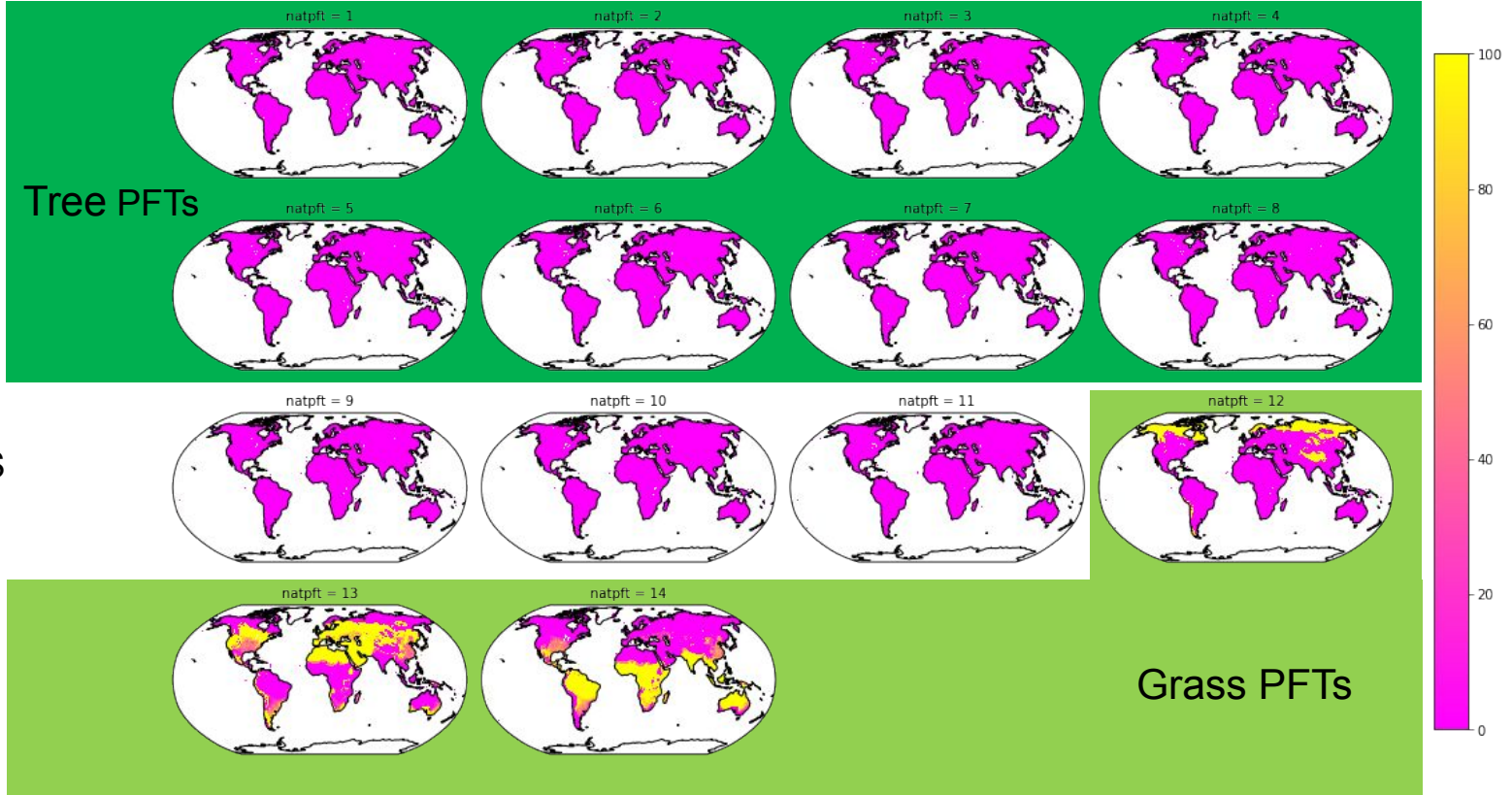
PFT indices correspond to “big-leaf” PFTs; an additional mapping is required to weight to FATES PFTs

Rangeland PFT mapping



PFT indices correspond to “big-leaf” PFTs; an additional mapping is required to weight to FATES PFTs

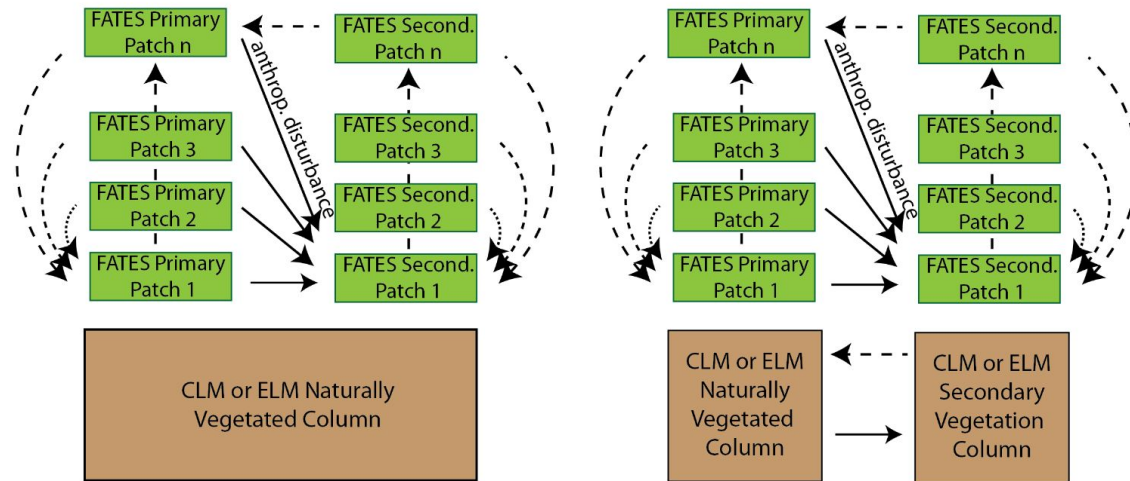
Pasture PFT mapping



PFT indices correspond to “big-leaf” PFTs; an additional mapping is required to weight to FATES PFTs

Longer term land use infrastructure need

- Develop a patch : column correspondence
 - All patches with the same categorical label together on their own column; only patches with a given categorical label on a given column
 - Allows irrigation, fertilizer, etc
 - Also would allow nutrient and other limitations to secondary forest succession
 - Also could extend to allow some natural disturbance (e.g. boreal fire) to directly impact soil dynamics (e.g. permafrost)



What else is going on right now in FATES? A brief update

- **Developments**

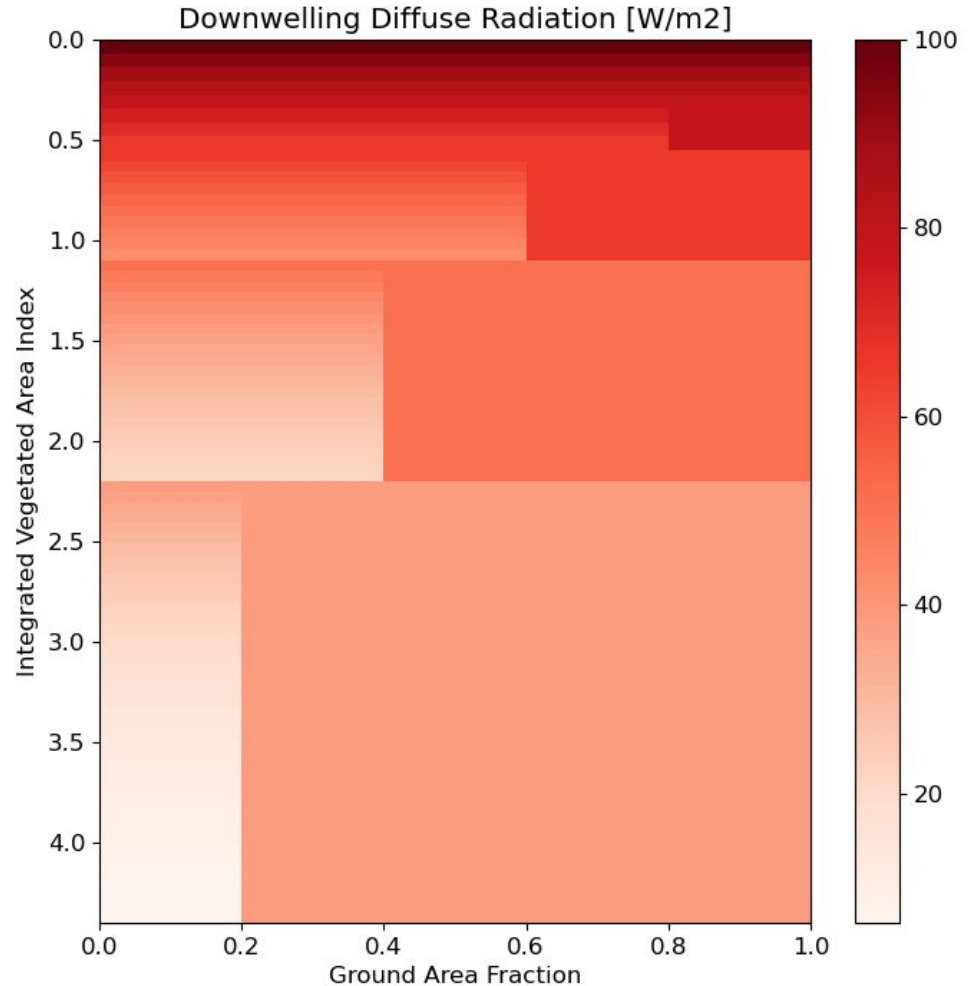
- Nutrients (See Knox et al preprint: [10.22541/essoar.167810418.80767445/v1](https://doi.org/10.22541/essoar.167810418.80767445/v1))
- Radiative transfer: Two-stream vs Norman (Ryan Knox, More details on next slides)
- Phenology (Marcos Longo)
- Seed Dispersal & Recruitment (Yanlan Liu, Greg Lemieux, Adam Hanbury-Brown)
- Mass-based vs. Area-based logging drivers (Shijie Shu, Jennifer Holm)
- Lots of other things

- **Calibration**

- Global SP-mode calibration (Rosie Fisher and Adrianna Foster)
- Global nocomp-mode calibration (Jessie Needham)
- Lots of site and regional work by lots of people

FATES Two-Stream Radiation

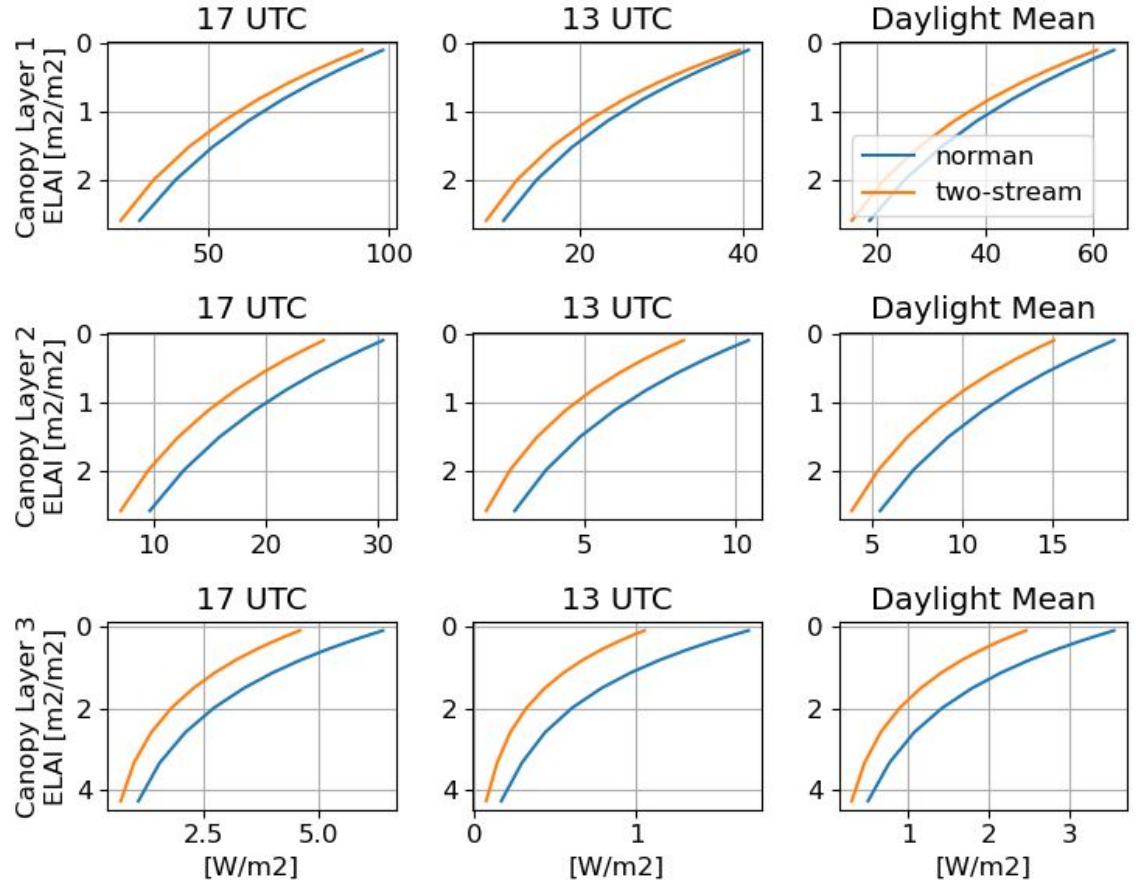
- PR: [1036](#)
- Partitions vegetation canopy into discrete scattering elements where different optical properties, can be vertical or parallel in nature
- Generalized Matrix Solution based on Longo et al. 2019
- Parameters based on Bonan et al. (multi-layer canopy work, in prep)



FATES Two-Stream Radiation

- Results similar but subtly different than Norman (existing) radiation
- Test Simulation: Barro Colorado Island Panama, Inventory Initialization, Local Meteorology, Forest Dynamics OFF

Diffuse PAR Intensity Profiles [W/m²]



Thanks!