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Where we use or plan to use CLM

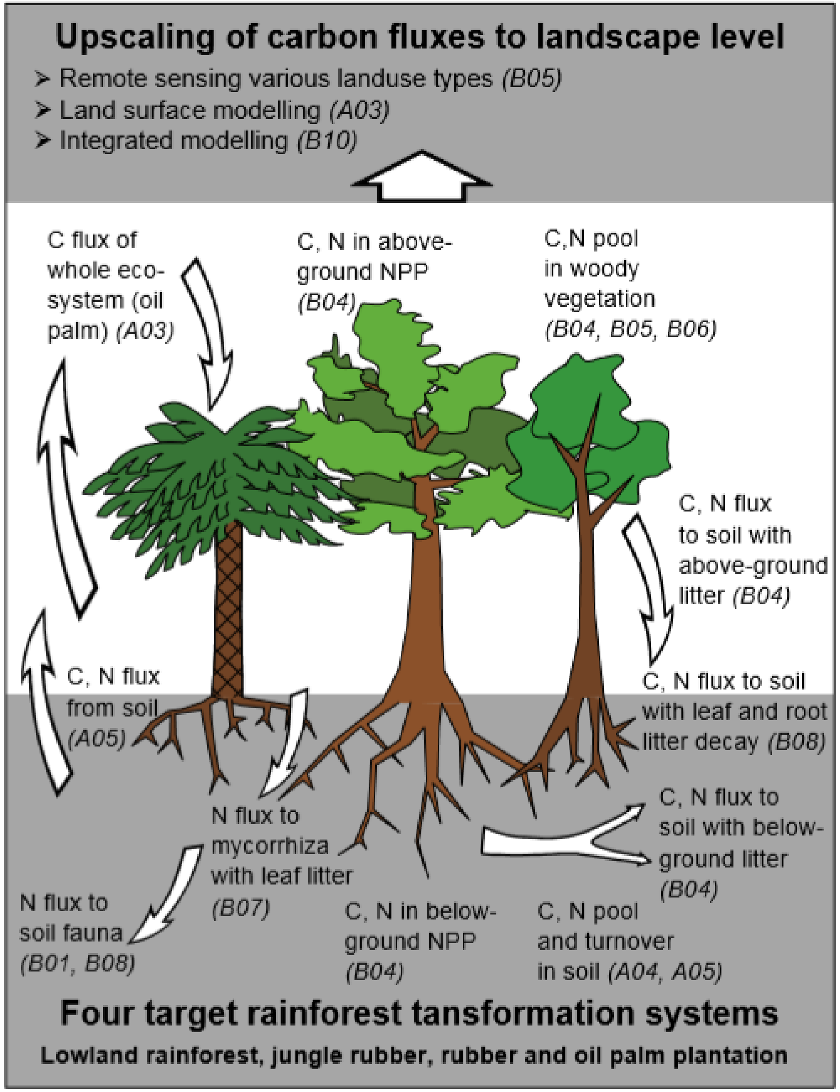
1. Tropical Lowland Rainforest Transformation Systems (Sumatra, Indonesia) (Yuanchao Fan)
2. Effects of management/composition on forest response to extreme climate events (Rijan Tamrakar)
3. Introducing process based representations of soil C dynamics (myself)

Tropical Lowland Rainforest Transformation (Sumatra, Indonesia)

The background

- Tropical lowland forests are experiencing the strongest losses worldwide, with regions in Sumatra seeing some of the fastest transformations.
- These natural lowland forests are transformed into rubber and oil palm plantations.
- Similar intensive land use change is expected to continue happening extensively in Indonesia.

Tropical Lowland Rainforest Transformation (Sumatra, Indonesia)



Tropical Lowland Rainforest Transformation (Sumatra, Indonesia)

Simulating the Oil Palm (Yuanchao Fan)

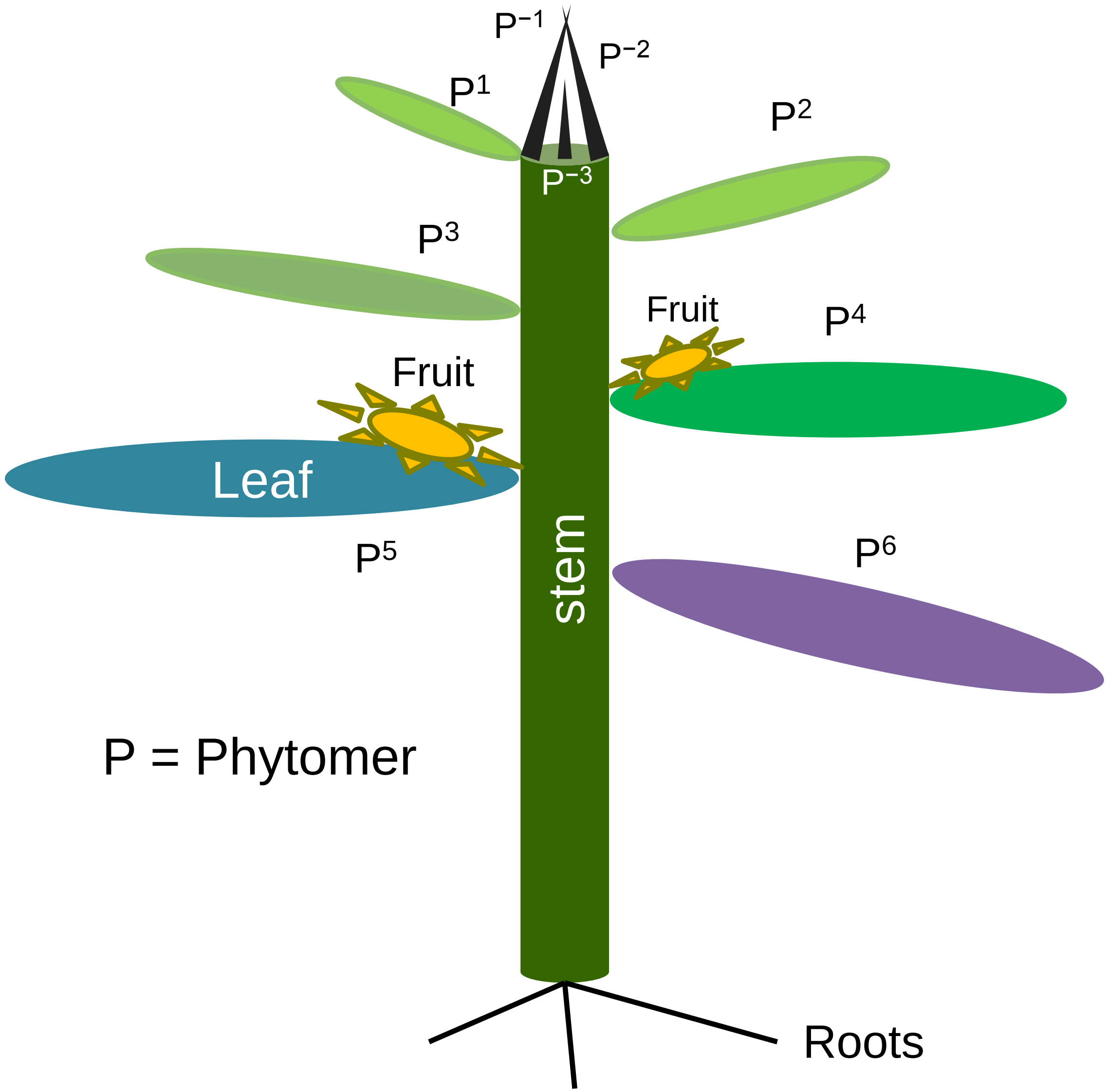
- Evergreen phenology
- Seasonal-deciduous phenology
- Stress-deciduous phenology
- Annual crop phenology
- **Perennial evergreen crop phenology**
  - **Oil Palm phenology**

Palm Phenology

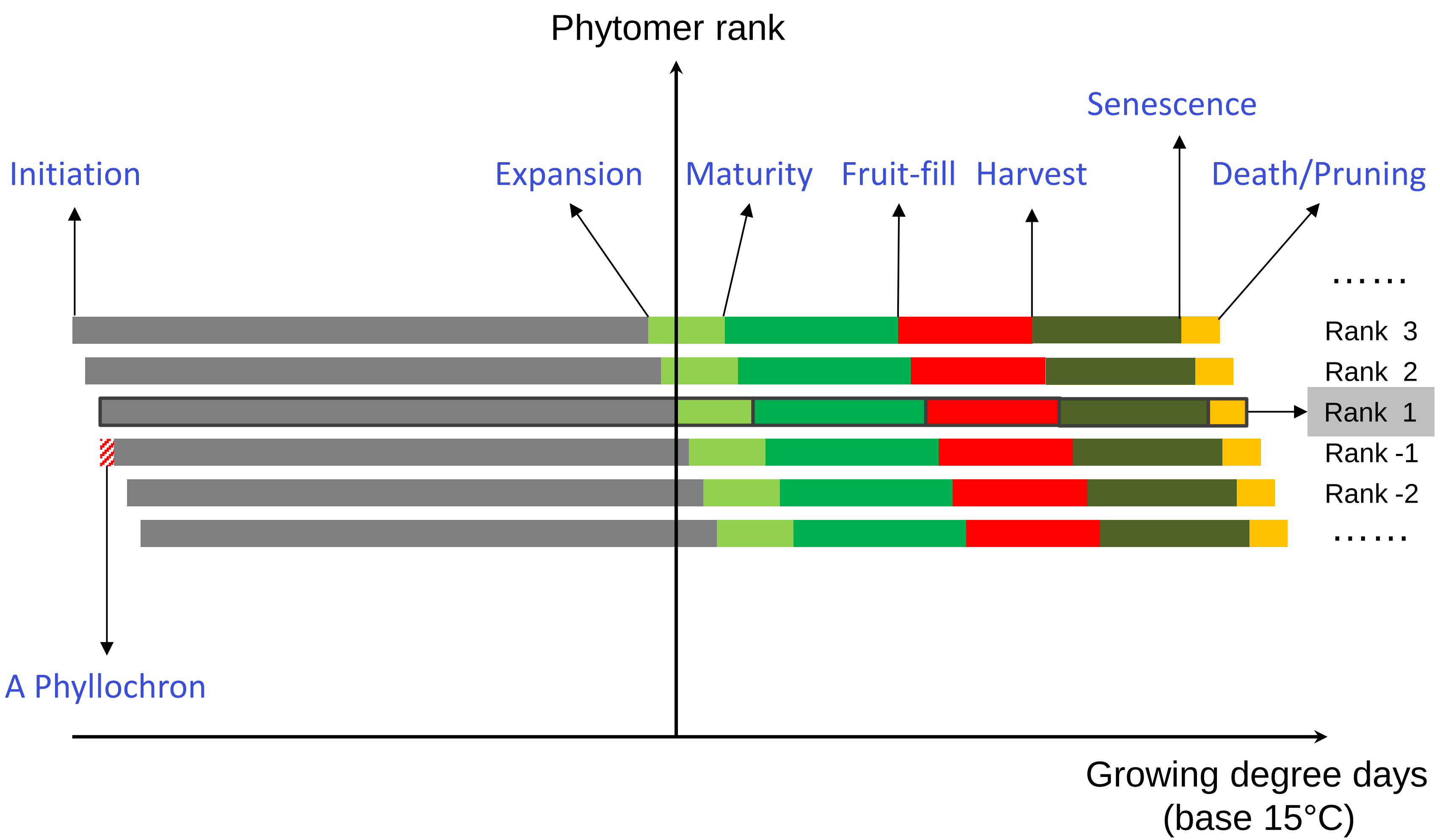
- Planting to leaf initiation
- Leaf expansion
- Leaf maturity
- Fruit fill
- Fruit harvest and output
- Leaf senescence and pruning

The oil palm PFT structure

1. leaf growth
2. fruit-fill
3. harvest
4. leaf pruning



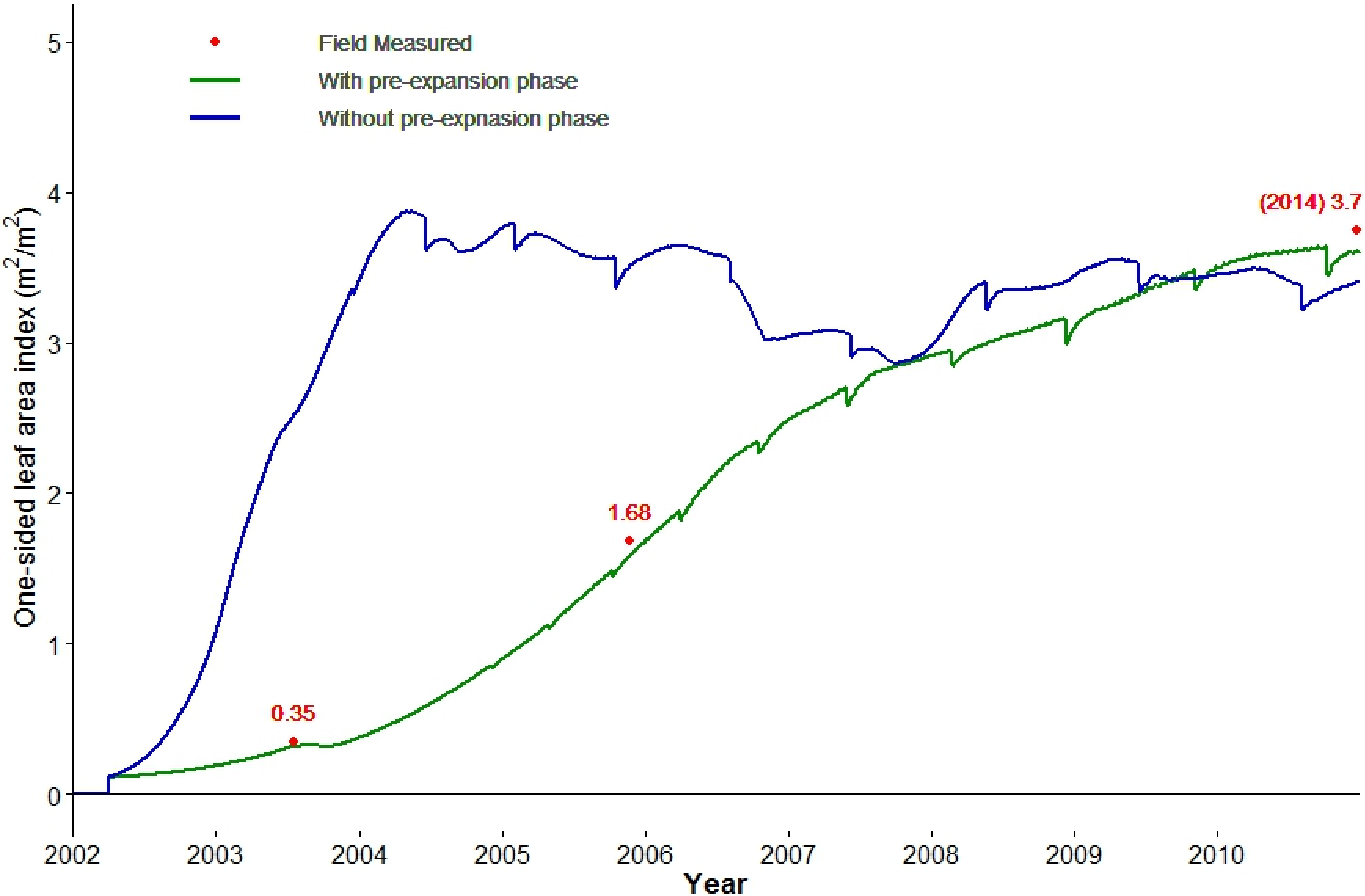
Palm Phenology



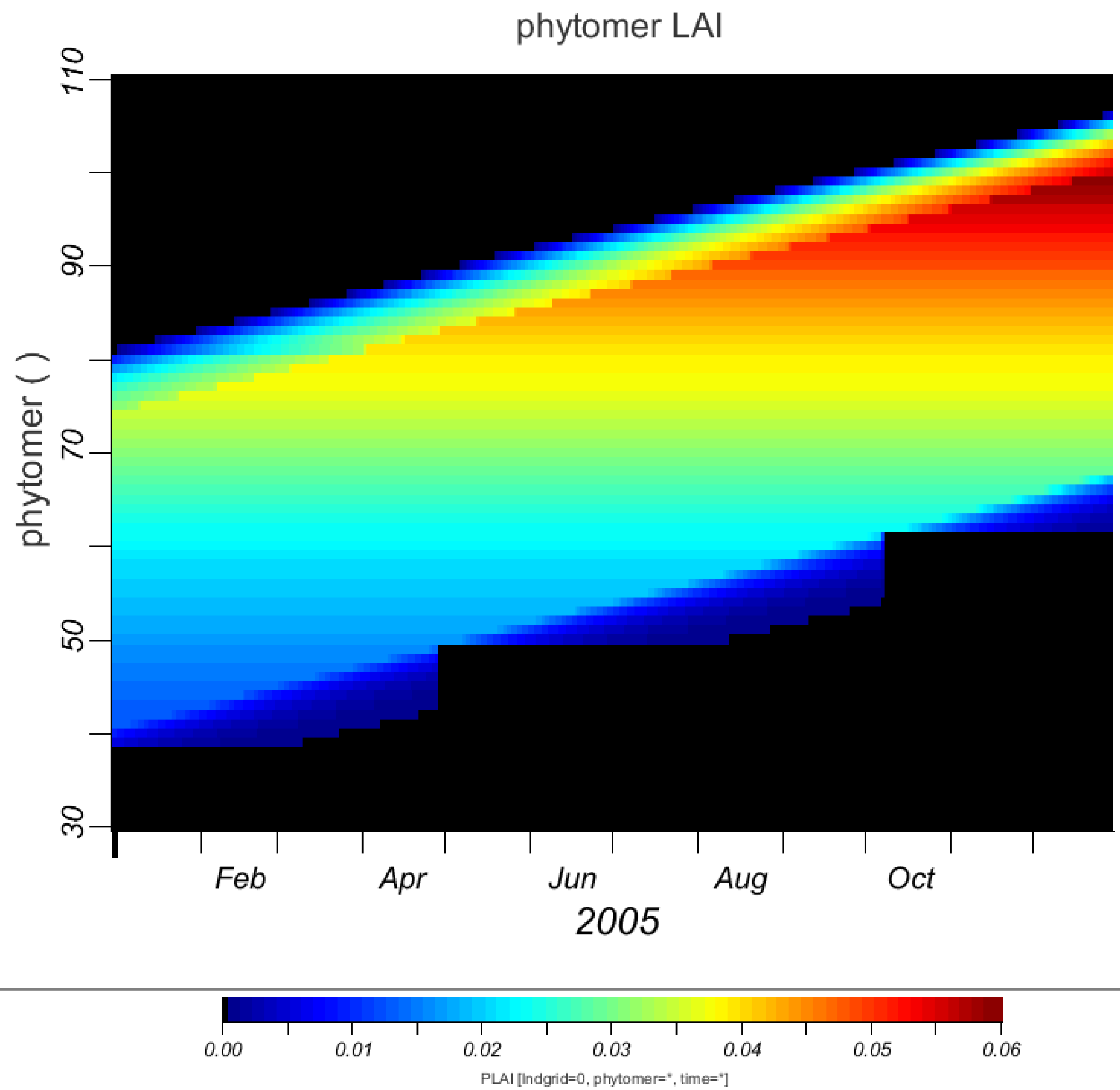
The spear leaf

- The “spear” leaf develops for nearly 2 years before it expands to be a photosynthetically active leaf

Leaf area index



Pruning


phytomer LAI
phytomer ( )
110
90
70
50
30
Feb
Apr
Jun
Aug
Oct
2005
0.00
0.01
0.02
0.03
0.04
0.05
0.06
PLAI [lndgrid=0, phytomer=*, time=*]

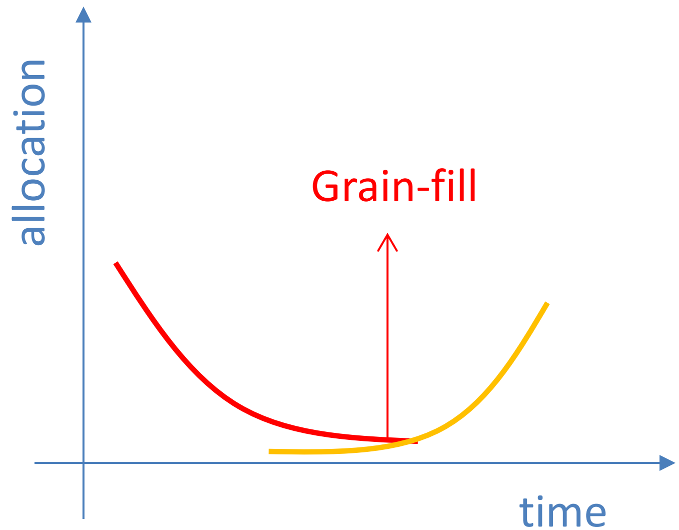
Trophic Competition

- Vegetative demand and reproductive demands compete under stress conditions
- *Supply:Demand* ratio affects inflorescence gender ratio and abortion rate
- $RSD = \frac{C_{avail}}{D_{veg} + D_{rep}}$

- $rsex = m_1(1 - RSD)$; when -27 <= Rank <= -21
- $rabort = m_2(1 - RSD)$; when 7 <= Rank <= 12

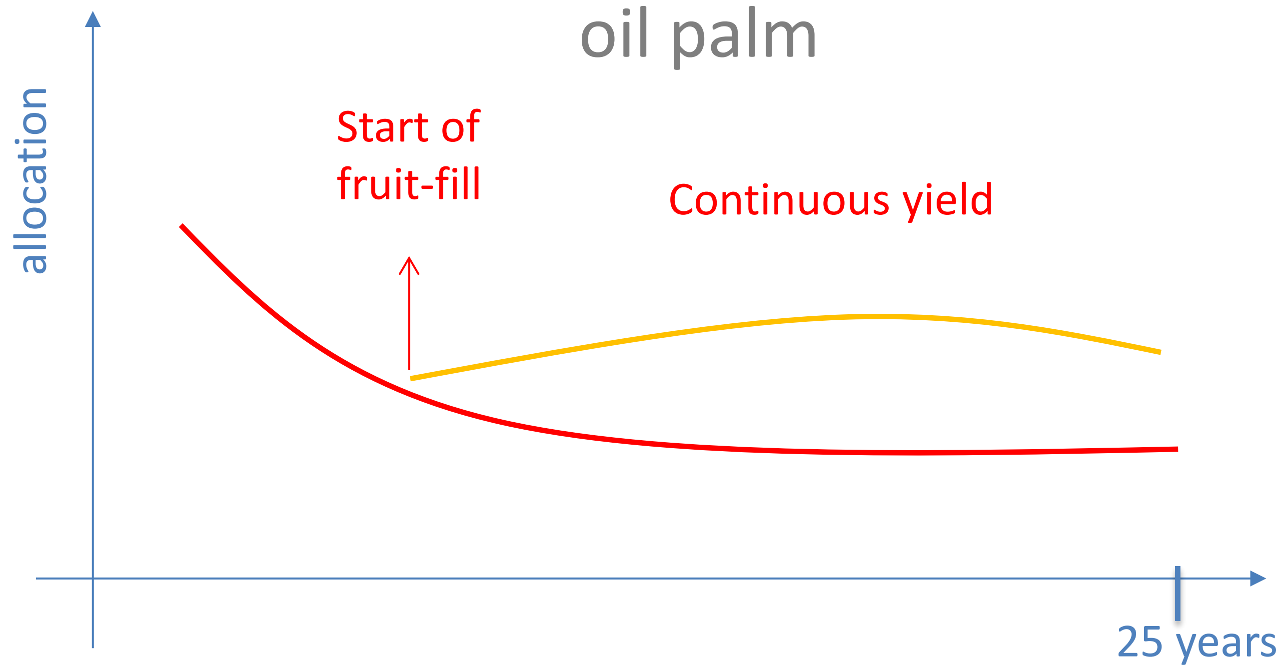
Carbon and Nitrogen Allocation

- Annual crops: allocation to leaf/stem/root decreases continuously until grain-fill, whereas allocation to grain increases from grain-fill till harvest



Carbon and Nitrogen Allocation

- The oil palm maintains LAI and produces continuously throughout its entire life cycle
- Allocation to leaf/stem/root and fruit needs to be balanced



Two-step allocation

- Plant level: allocate available C and N to root, stem, and overall leaf (vegetative) + overall fruit C/N pools (reproductive)
- Phytomer level: allocated C and N to the leaf and fruit pools are partitioned between all phytomers

Objectives

Understand and model changes in:

- Albedo
- Water/Energy Fluxes
- Carbon Cycle

Then scale up to the region and predict for different future scenarios

Introducing process based representations of soil C dynamics

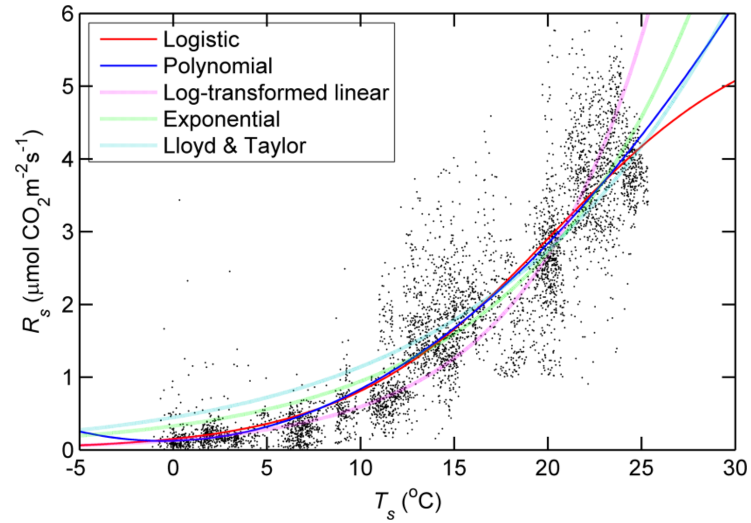
- A theory based approach is the better option, even if agreement with data shows little improvement
- Enough theory and evidence is available to know that we can do better
- Land Use Change (e.g. Indonesia) = Big Experiment

Introducing process based representations of soil C dynamics

Temperature

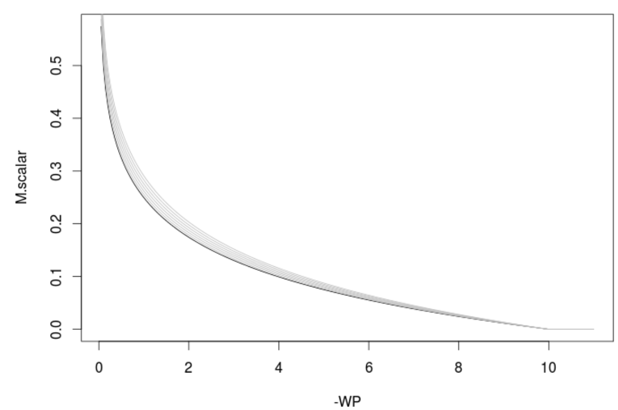
$$r_{tsoil} = Q_{10}^{\left(\frac{T_{soil,j} - T_{ref}}{10}\right)}$$

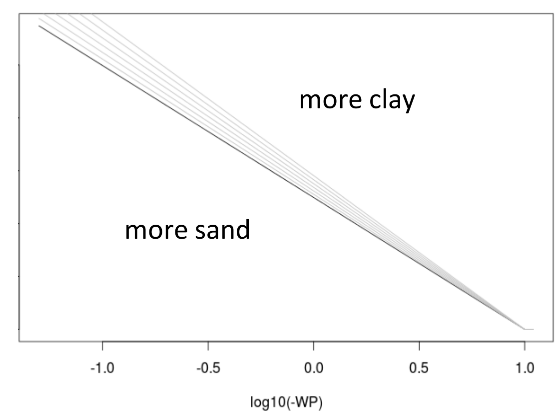
Q10 = 1.5



Moisture

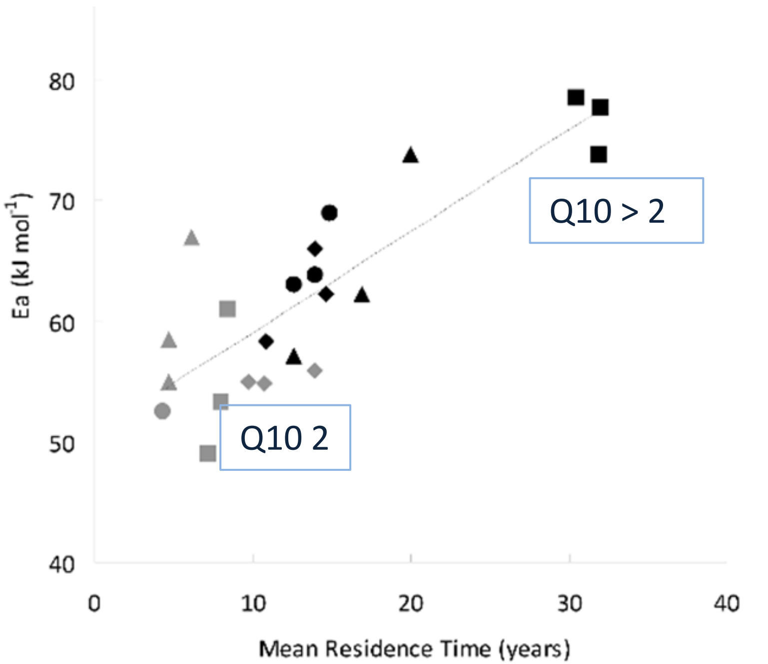
$$r_{water} = \sum_{j=1}^{5} \begin{cases} 0 & \text{for } \Psi_j < \Psi_{min} \\ \frac{\log\left(\Psi_{min}/\Psi_j\right)}{\log\left(\Psi_{min}/\Psi_{max}\right)} w_{soil,j} & \text{for } \Psi_{min} \le \Psi_j \le \Psi_{max} \\ 1 & \text{for } \Psi_j > \Psi_{max} \end{cases}$$





Introducing process based representations of soil C dynamics

Temperature



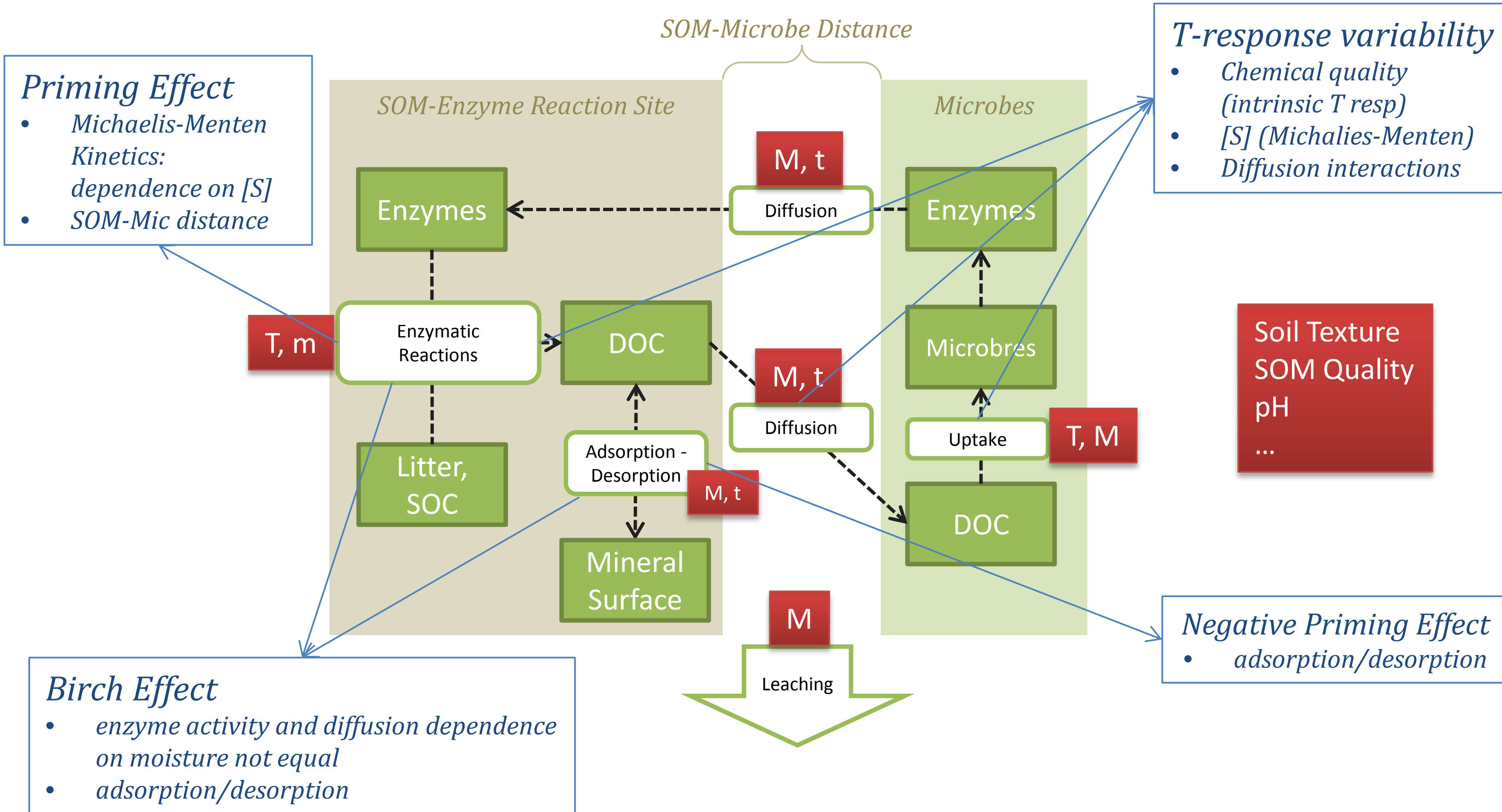
Lefevre, Barre, Moyano, et al. GCB, 2014

- In agreement with theory
- Relates T-sensitivity to pool turnover time

- Soil Incubations show higher Q10 (>=2)
- Several studies suggest a higher sensitivity for slower pools.
- Slow pools have low contributions to R_{eco}, therefore will not noticeably influence short term R_{eco} T sensitivity
- However, they will respond to T changes in longer time periods -> new equilibrium

Introducing process based representations of soil C dynamics

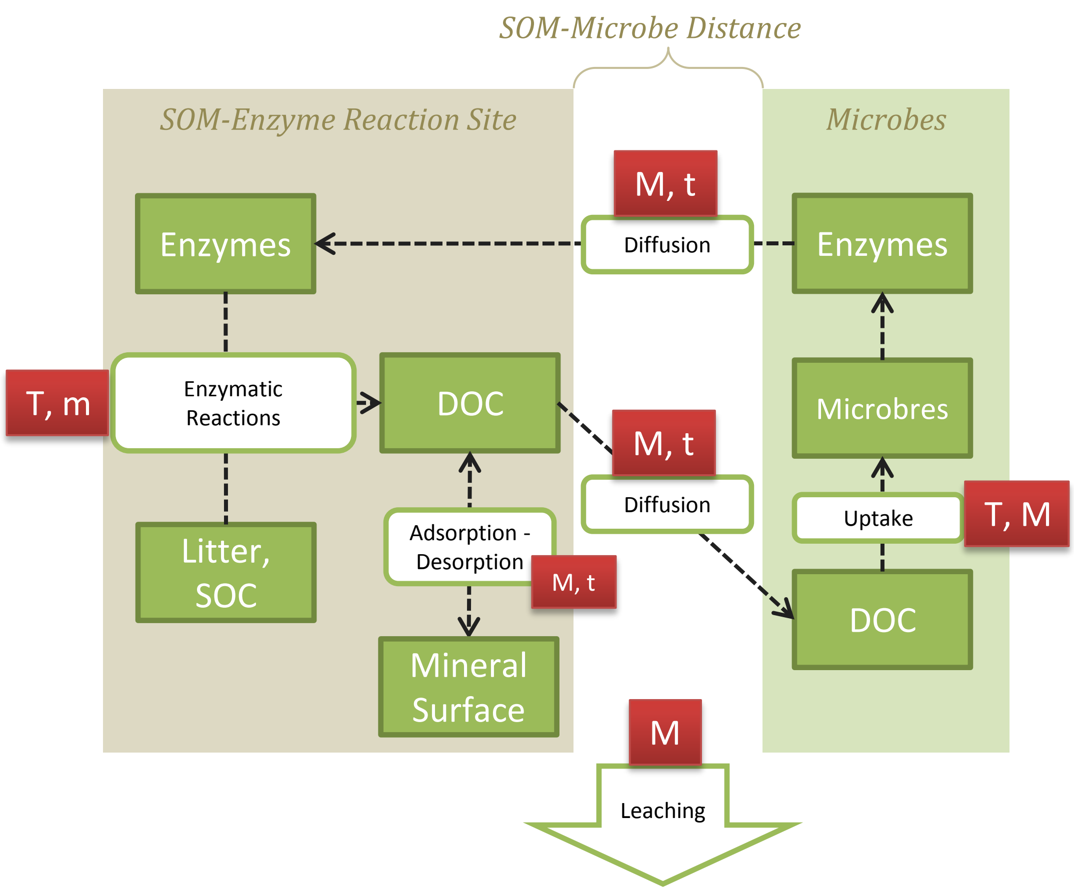
Moisture



Manzoni, Moyano, et al. in prep.

Introducing process based representations of soil C dynamics

Moisture



Moisture effect through C and enzyme diffusion:

$$F_S = h_S\left(C_S^w - C_{S,0}^w\right)$$

$$h_S(\theta) = \frac{vD_S(\theta)}{\delta^2}$$

δ : characteristic distance between microbial cells and C substrate

That's it

=============== SUCCESSFUL TERMINATION OF CPL7-CCSM ===============

=============== at YMD,TOD = 10106 0 ===============

=============== # simulated days (this run) = 5.000 ===============

=============== compute time (hrs) = 0.001 ===============