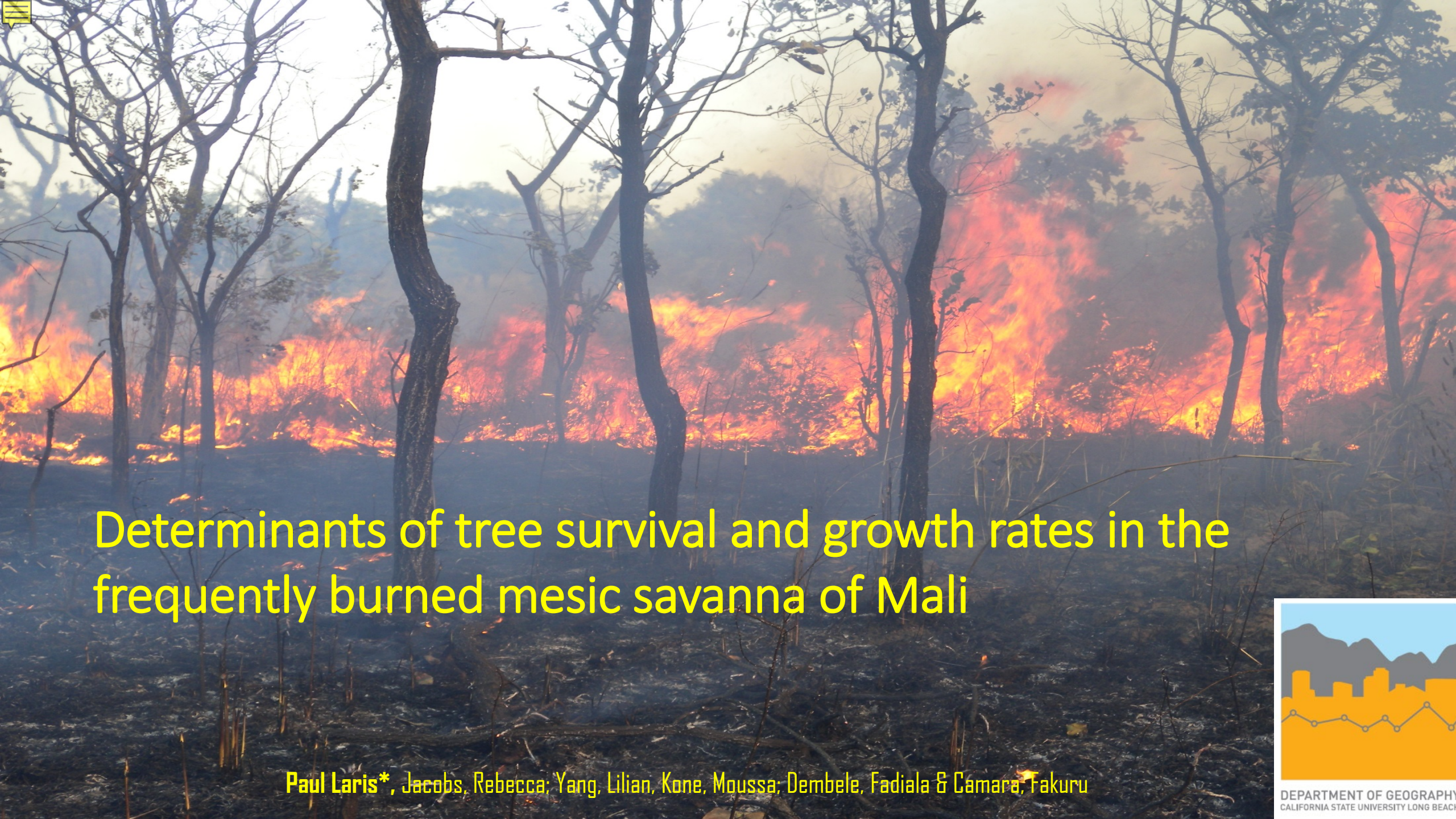

Determinants of tree survival and growth rates in the frequently burned mesic savanna of Mali

Paul Laris*, Jacobs, Rebecca; Yang, Lilian, Kone, Moussa; Dembele, Fadiala & Camara, Fakuru

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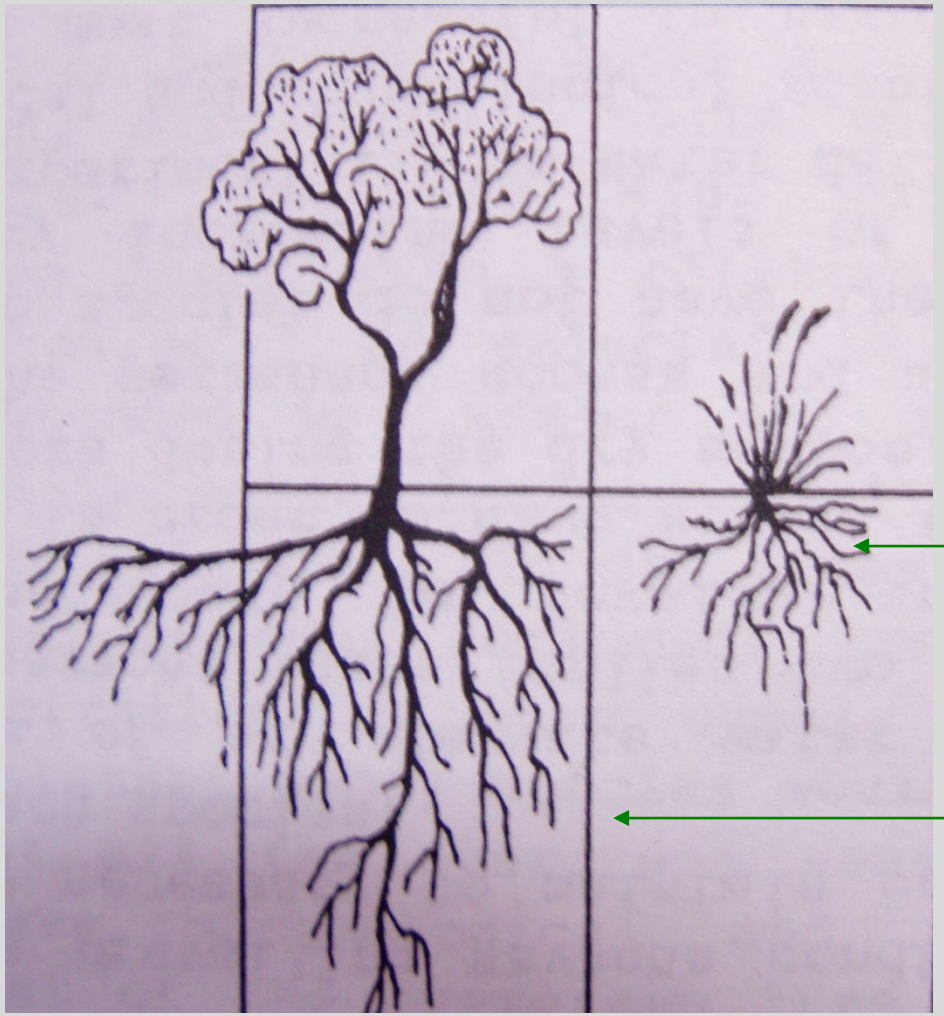
The Savanna Conundrum:

Savannas are by definition a mix of trees and grasses, but what determines the ratio?

Classic Competition Model for Tree-Grass Equilibrium



Resource partitioning

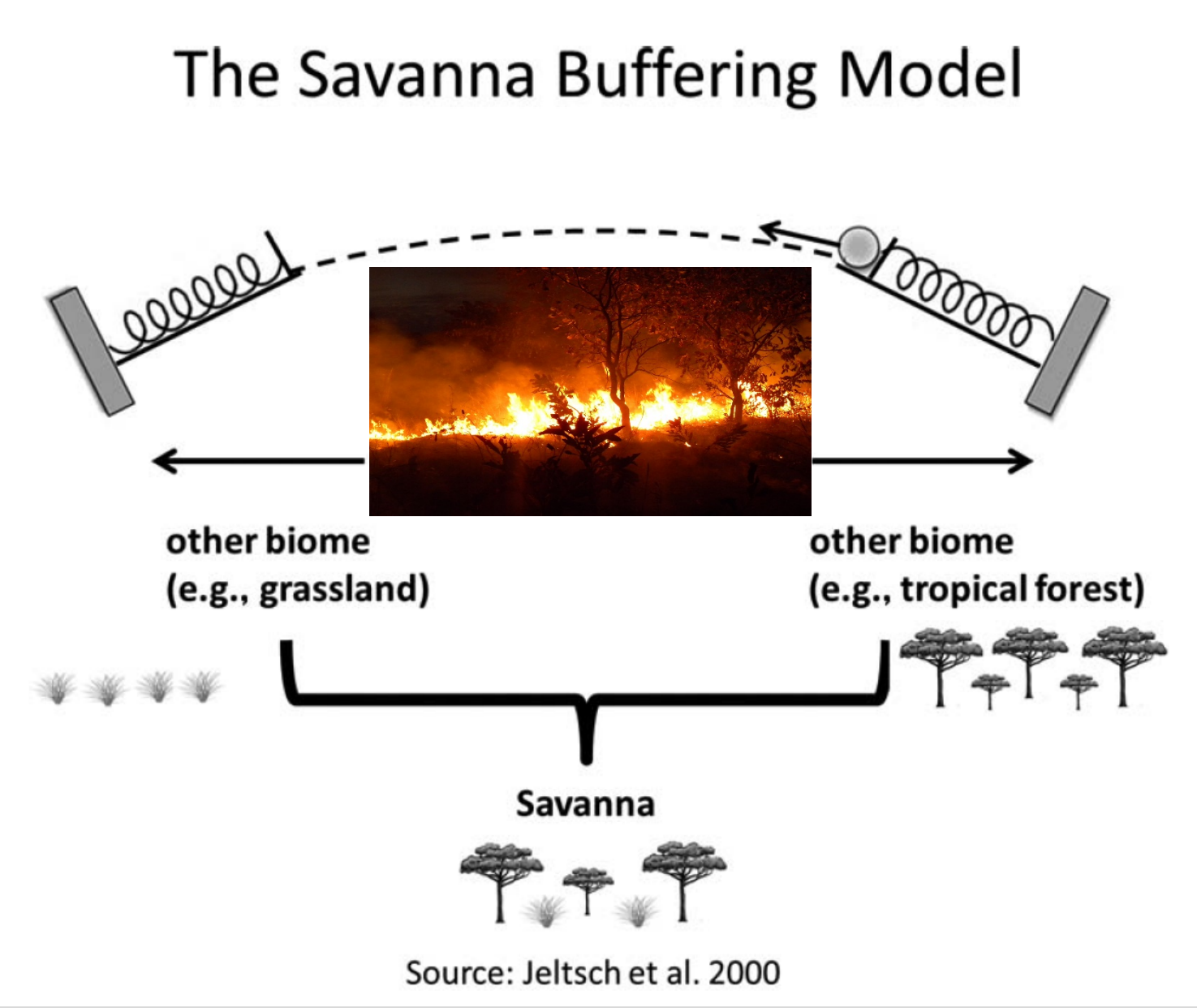
Grasses tap upper water table

Trees tap lower water table

Source: Walter 1987

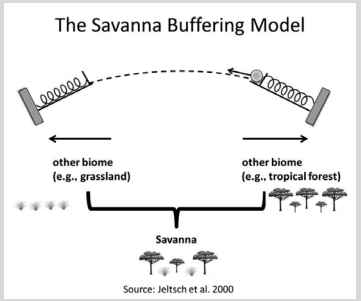
The Buffering Model for Tree-Grass Co-existence

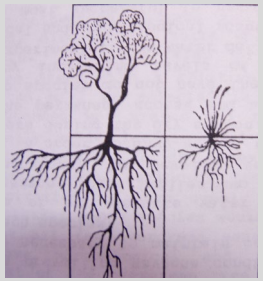
In mesic savannas, the system is disturbance (fire) driven because rain fall is sufficient to support forest

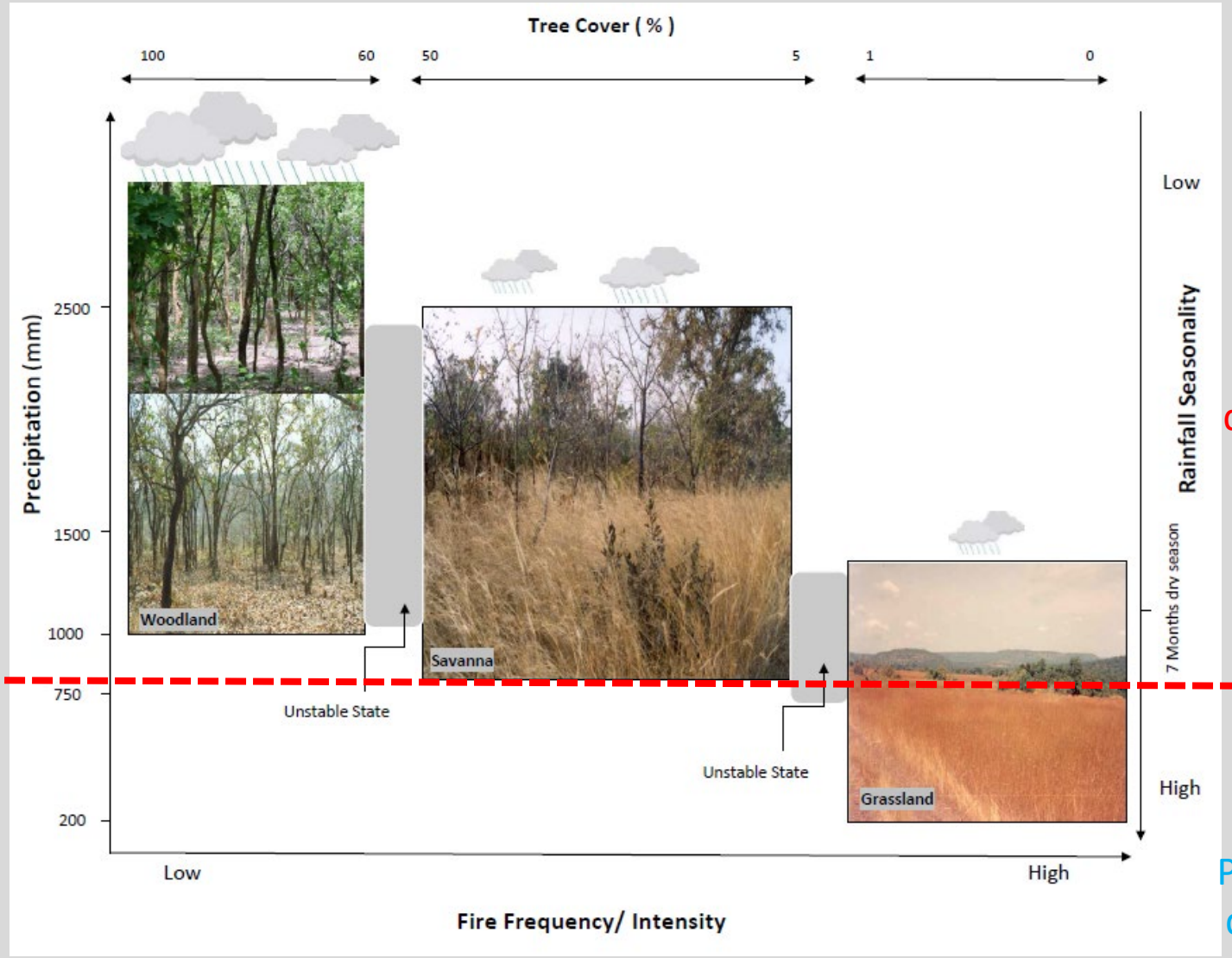


Fire-Driven (Mesic) Savanna Ecology Models

"Fire, which prevents trees from establishing, differentiates high and low tree cover, especially in areas with rainfall between 1000 mm and 2000 mm" (Staver et al 2011).







Fire determined

Mesic

Sankaran 750 mm for Africa

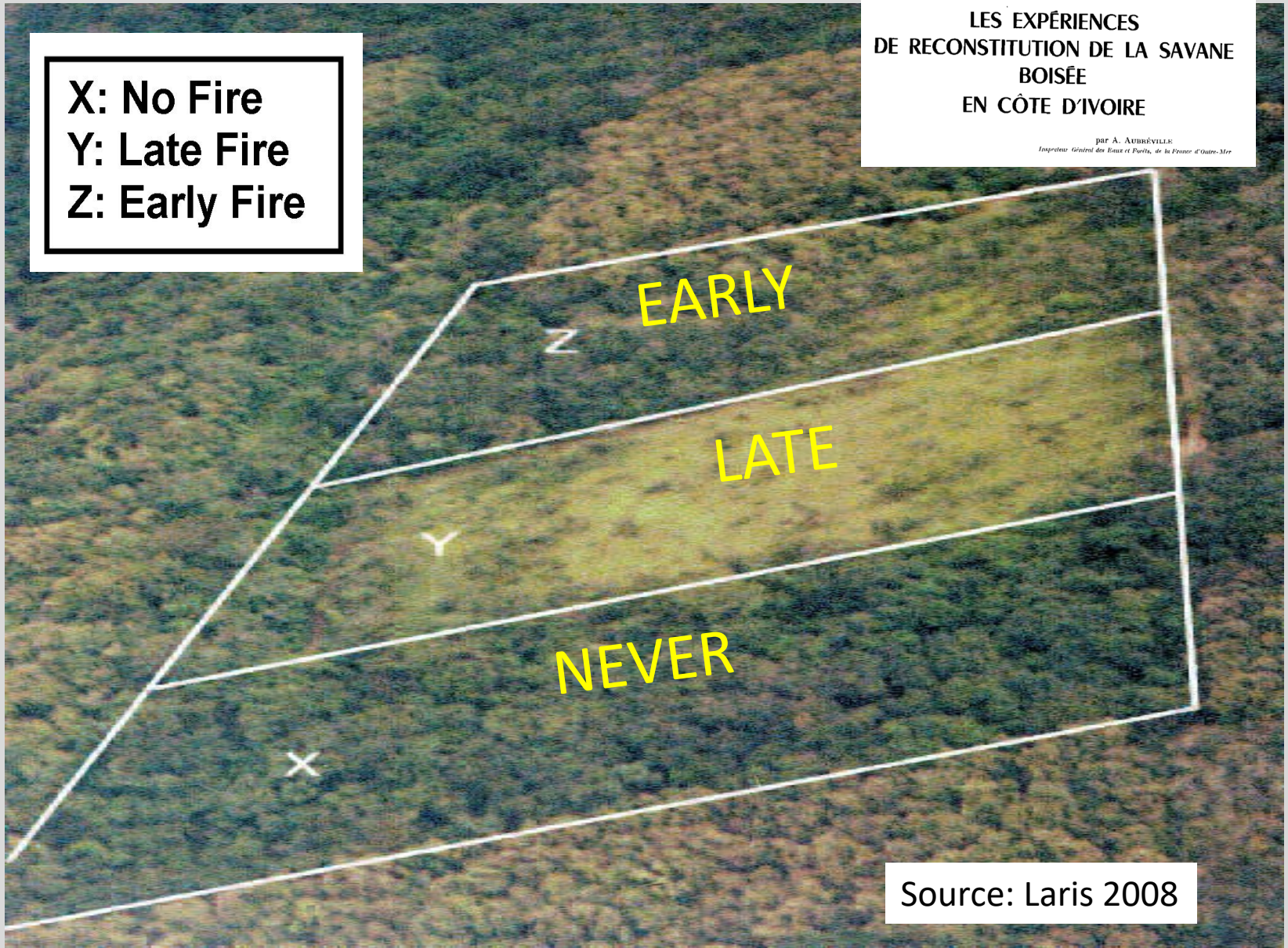
Semi-Arid

Precipitation determined

Aubréville's burning experiments: timing matters!

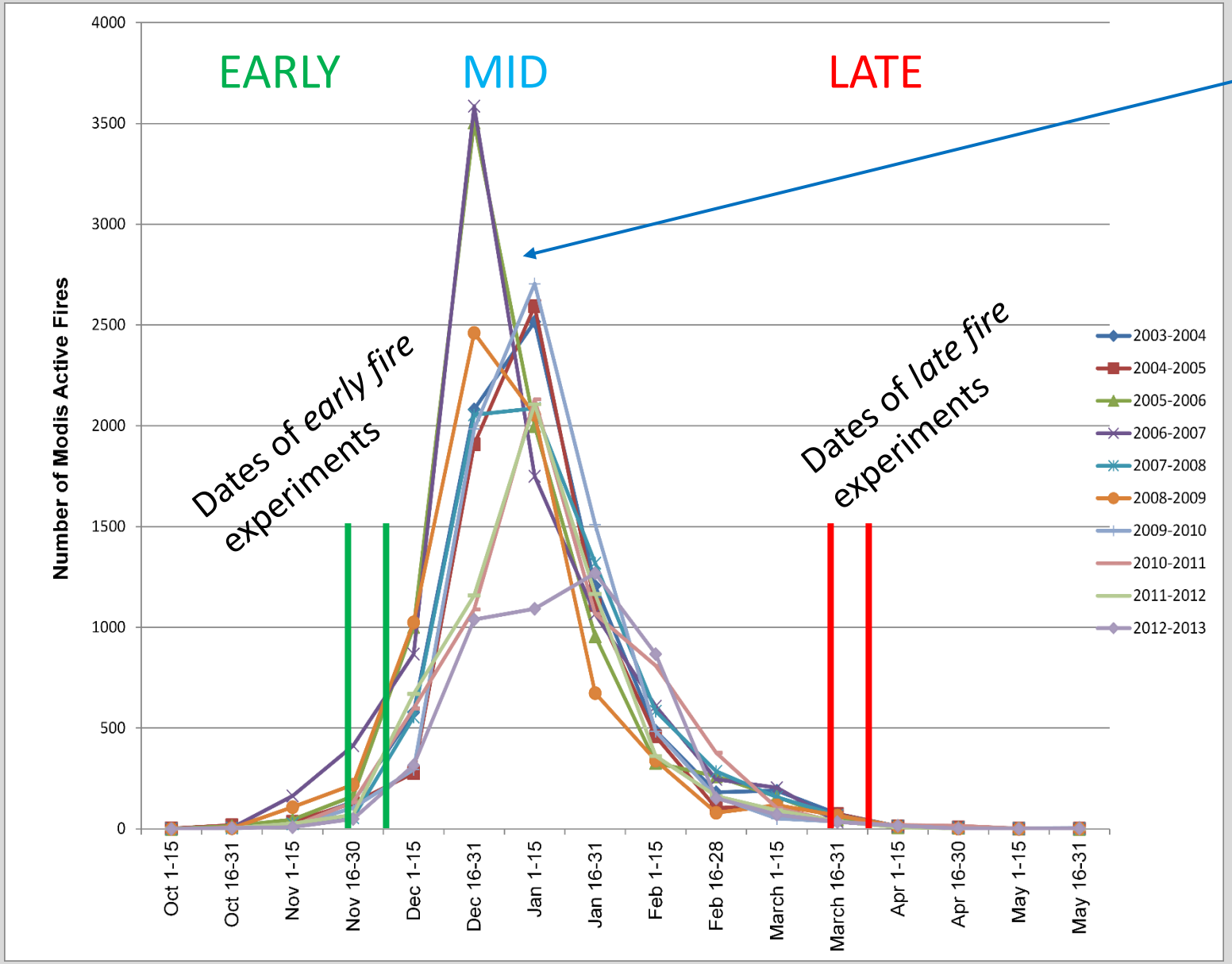
Fire regime determines tree cover in Mesic savanna

Late fires are **more intense** than early fires and thus more damaging to trees (**especially juveniles**).



Source: Laris 2008

Peak burning and **experiment** dates in southern savanna zone*



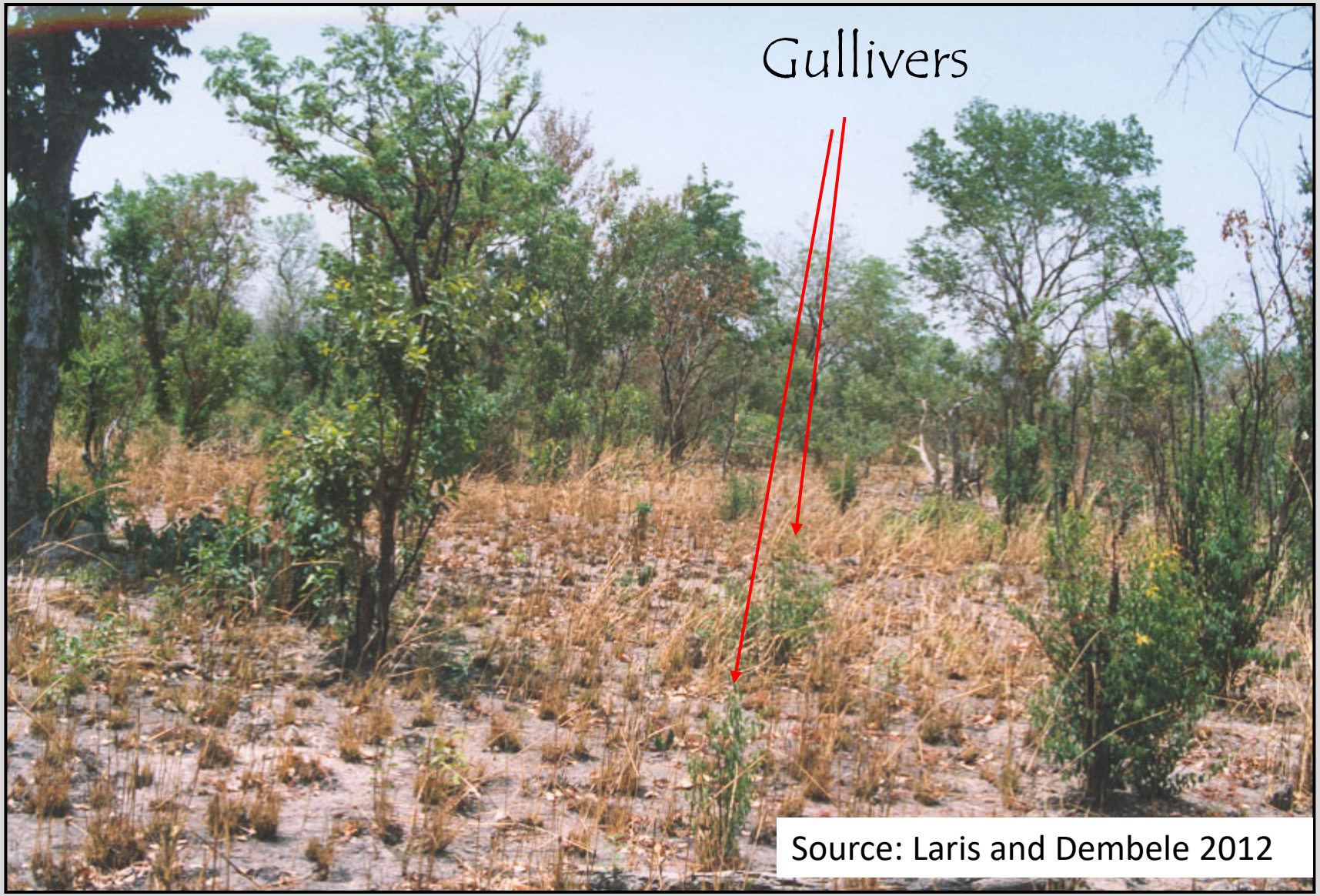
Lack of data from the middle fire season, when most fire occur

* Based on analysis of 10 years of MODIS active fire data

Laris et al 2017

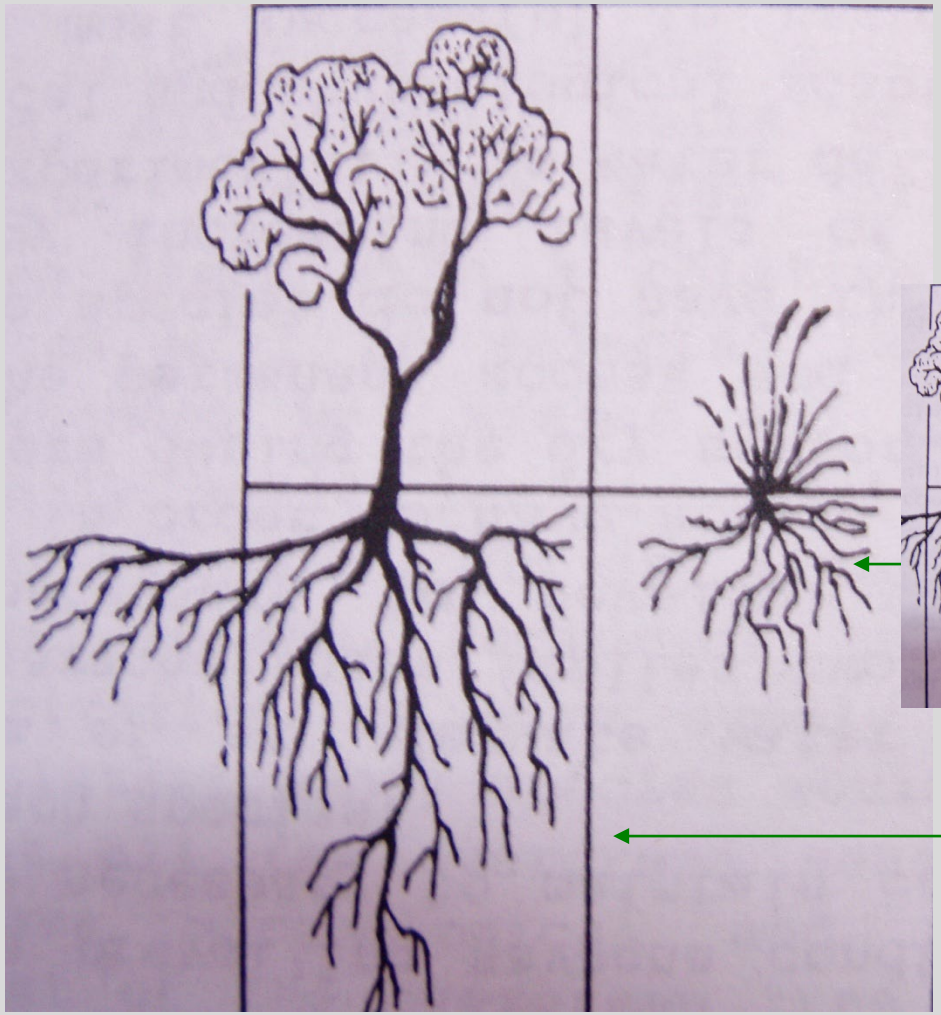
Gullivers are small trees caught in a fire trap by a perpetual cycle of fire

Fire trapped juvenile



Synthesis: What about juvenile trees?

Does competition affect them,
How much?



Resource partitioning

Juvenile Trees?

Grasses tap upper water table

Trees tap lower water table

Time for a synthesis of competition and disturbance models

- Do juvenile trees compete with grasses for water and resources even in mesic savannas?
- Is competition intense enough to slow tree growth significantly?
- If slowed, are juvenile trees more susceptible to die-back from fire?

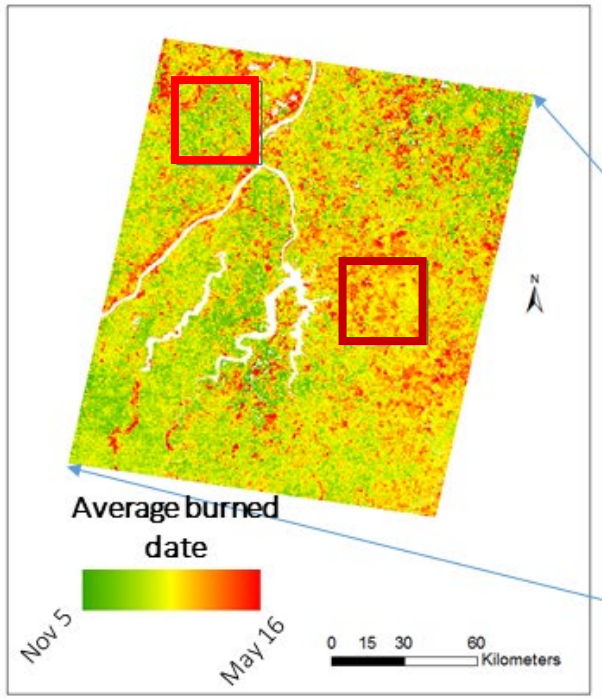
Most studies find that once trees reach height above flame scorch, they can escape fire. About 2 meters for many savannas.

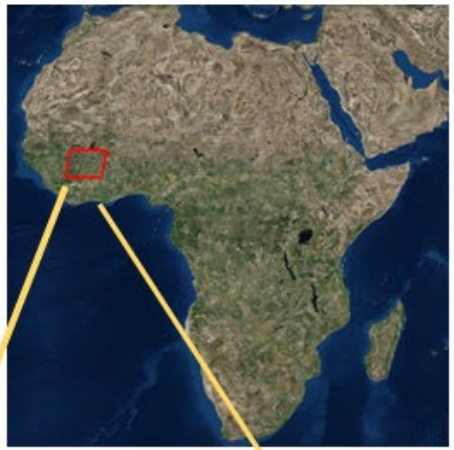
If juvenile tree growth is slowed by grass competition, do they suffer increased die-back from fire? Which type of fire?

Data needs:

- Fire intensity values and impacts on trees by season
  - Early
  - Middle
  - Late
- Tree growth rates with and w/o competition from grasses
  - Herbicide
  - Clipping
  - Hoeing
  - Grazing

Study areas in Mali





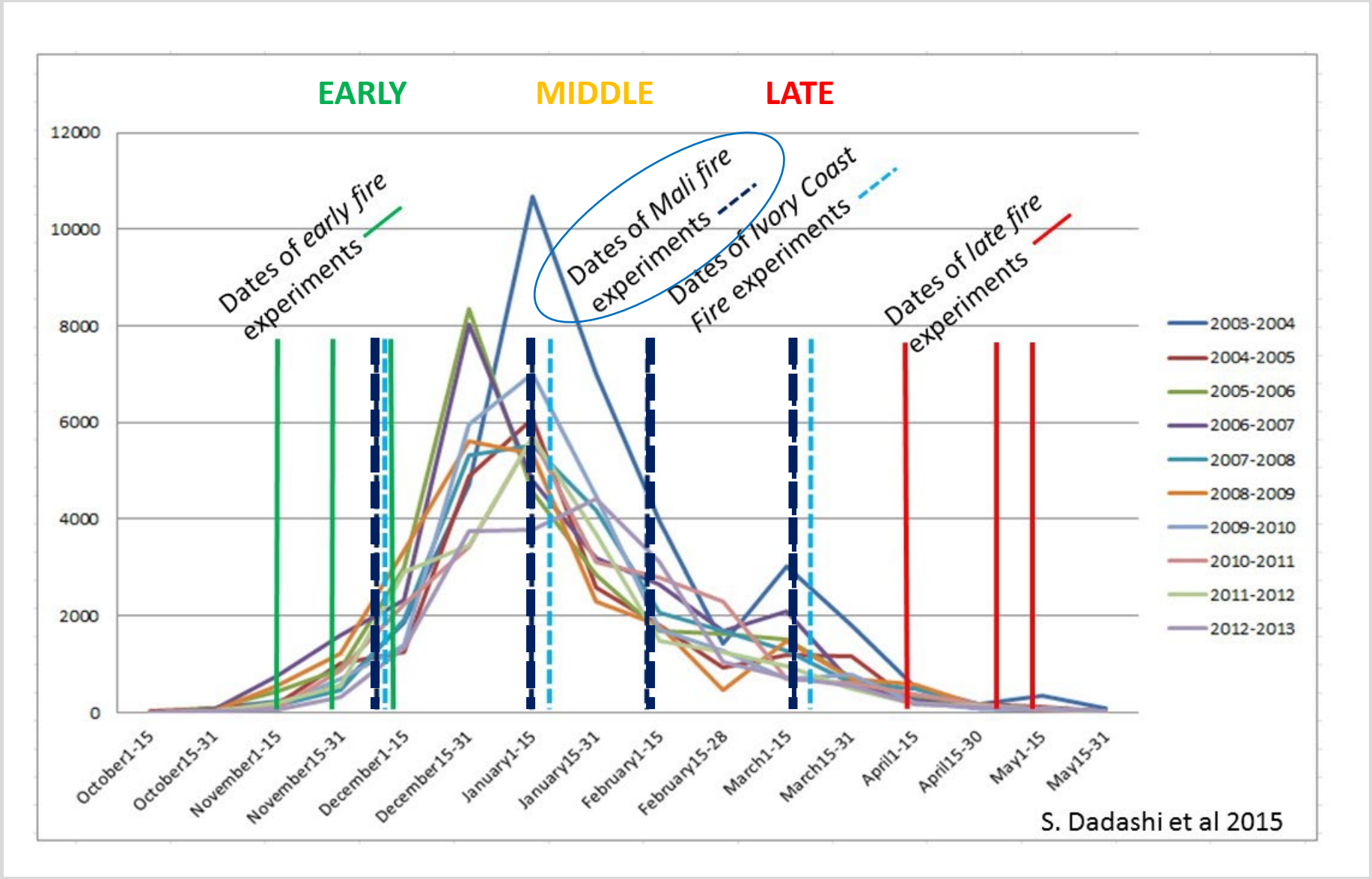
Sub areas for interviews and fire experiments

Dry (fire) season from Nov.-May

Field Methods: Combine three field studies

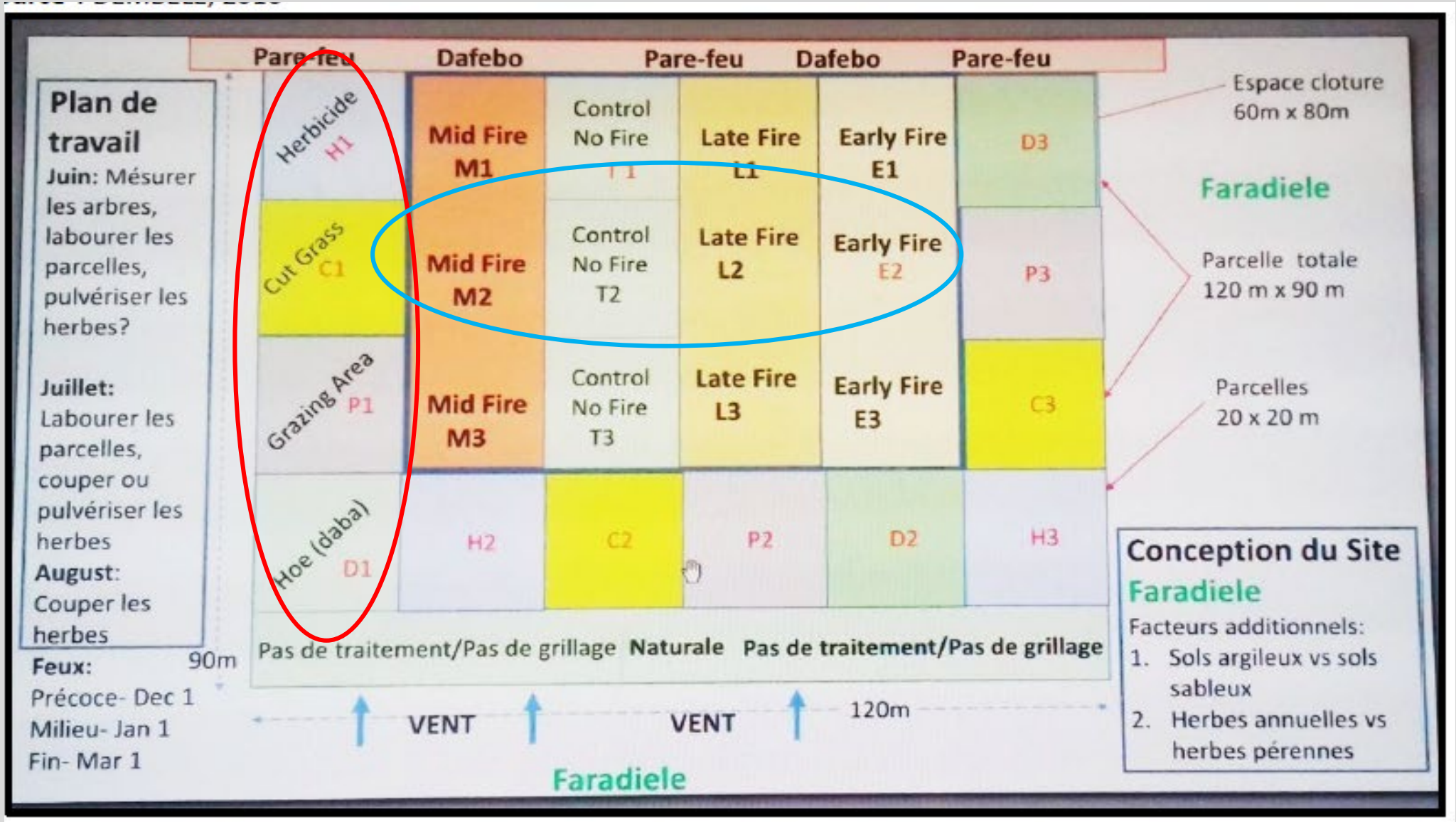
- Fire experiments on ***over 100*** 10x10 plots for two research sites
  - To determine fire intensity, severity and emissions
- Field survey of trees in areas burned early, middle and late
  - Determine tree death and survival as function of fire scorch ht.
- Long-term plots subjecting trees do different treatments (year 3 data)
  - To study tree growth under different conditions

Fire Timing: Early, middle and late fire experiments at each site (n=100+)



Collected tree survival data and fire scorch height after early, mid and late fires in the *field* (not plots)

Experimental site plan for Faradiele Village: Multiple Grass Treatments (t=3 years)



Do trees grow faster w/o grass competition?

Cut Grass*

Hoed Grass

Control plot

*Also used herbicides and cattle to reduce grass cover/competition

Early Burning on Tabou Village plot


RESULTS: What do field observations tell us?

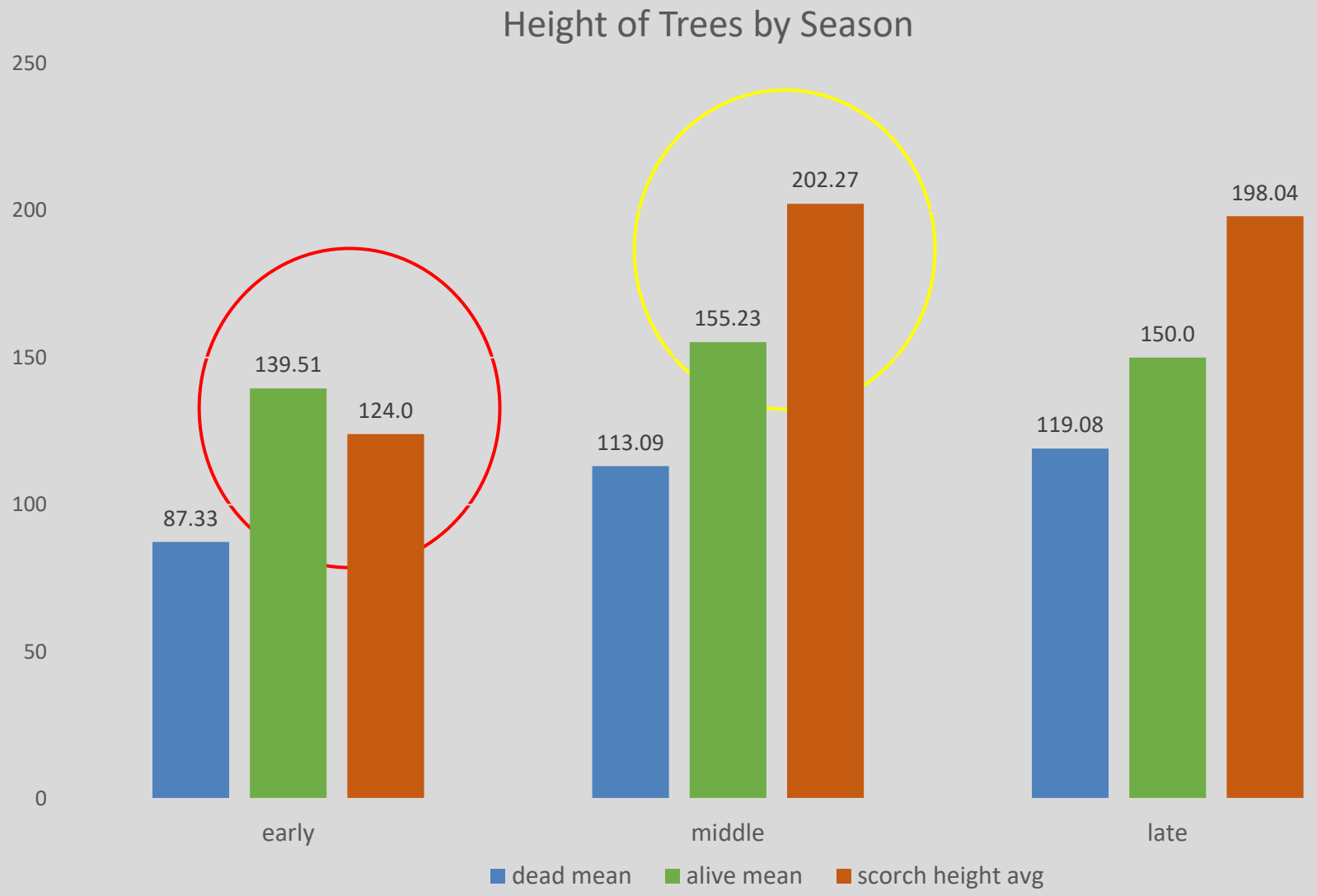
Mean Fire Characteristics by Study Period
Fire experiment plot data (n=100+)*

Mean fire characteristic	Early	Middle	Late
• Spread rate (meters/second)	0.030	0.024	0.034
• Scorch height (meters)	1.39	1.35	1.71
• Severity (percent biomass consumed)	85	86	93
• Byram's Fire-line Intensity	223	189	294

Fire intensity and severity are highest in late season, mid-season is closer to early than late season.
Intensity is *lowest* in mid season as is scorch height.

*note that results varied by fire type (head or back)

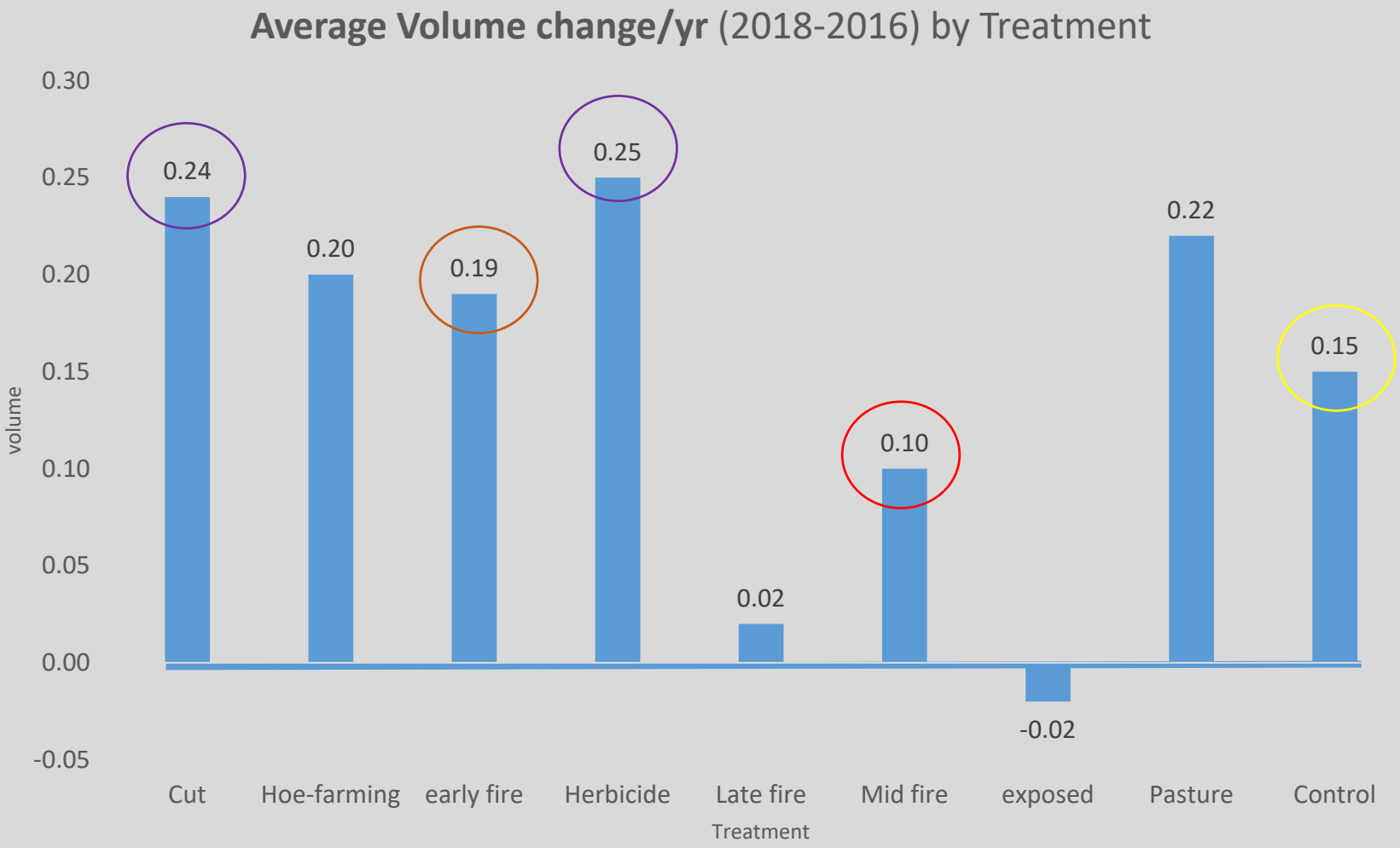
Effects of fire timing on tree survival (open savanna data)



Early fires have the shortest alive mean and dead mean and this correlates with the lower scorch height.

Mid and late season have higher dead and live means and higher scorch heights, indicating higher intensity and tree death

Tree growth data for Faradiele experimental plots



Herbicide and cutting had fastest growth rates (0.24-0.25)

Hoeing was 0.20

Control was 0.15

Early Season fire was 0.19

Mid season fire was 0.10

Late Season fire was 0.02

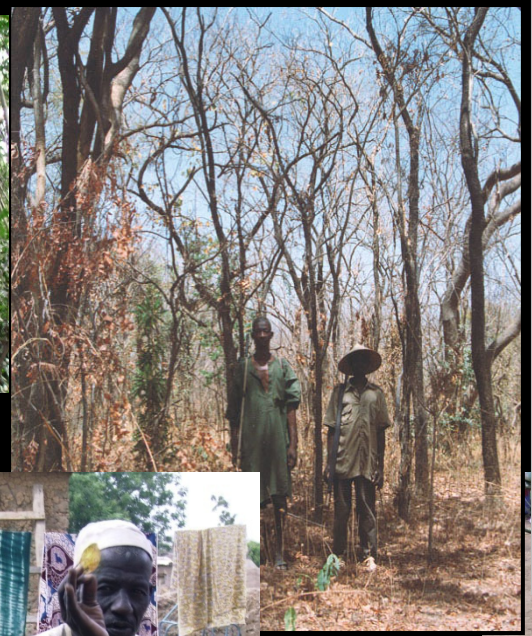
What to conclude?

- Plot data finds mid season fires are less intense than others (but this depends on grass species)
- Field data finds that tree survival heights vary by season, with early season significantly shorter than mid or late (supports Aubreville)
- Grasses do compete with trees and slow growth by 33-66%

Synthesis of Findings: *If juvenile tree growth is slowed by grass competition, do they suffer increased die-back from fire? And, which type of fire?*

- When grass competition is removed, trees grow roughly 50% faster.
- A 50% increase in growth rate moves trees from the “die-back” height to the surviving height for all fires.
- Early season fires appear to have a very beneficial impact on tree growth because they are less damaging **and** remove grass competition to increase survival chances (trees grow after burn).
- Would one season of grass removal increase tree cover significantly in a mesic savanna?

Thanks to all of those people in Mali and elsewhere who made the research possible



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