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# A hydraulically based model framework for the grass leaf meristem

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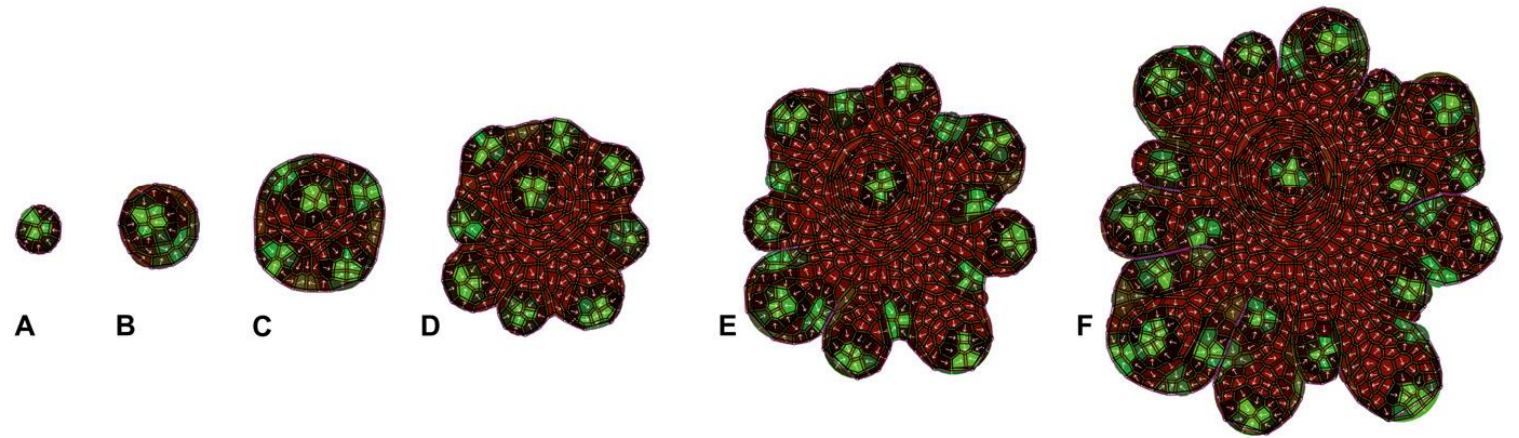
Submitted on 22 Aug 2024

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# Virtual Leaf

Merks et al. 2011

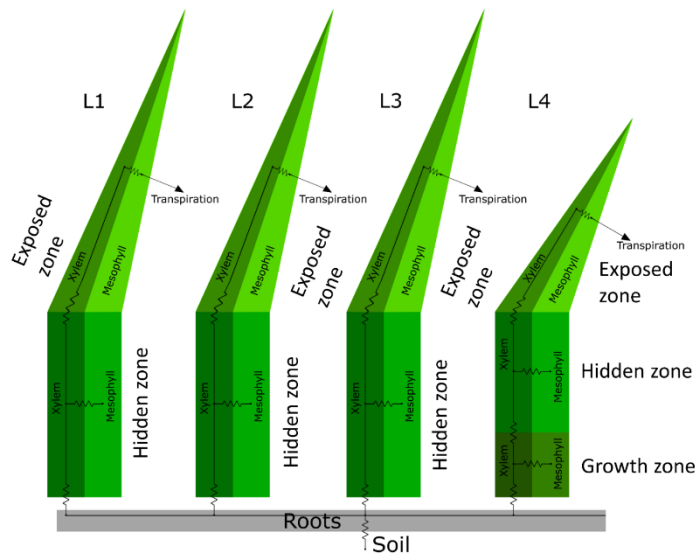


# Virtual Plant

Coussement et al. 2020



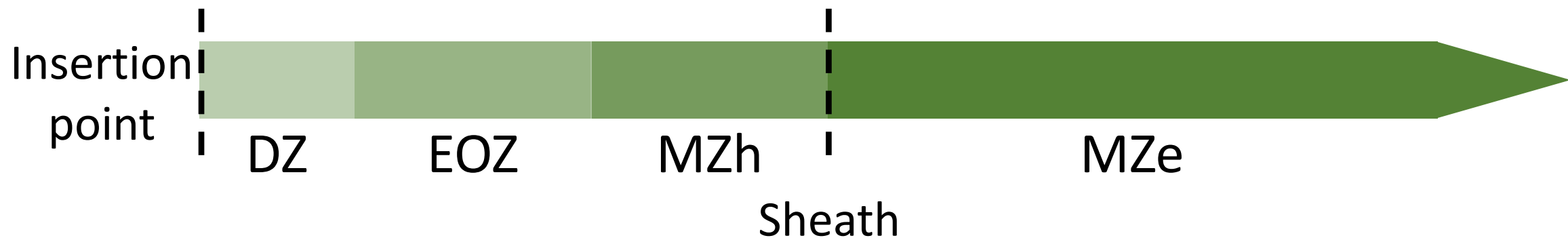
# A hydraulic model framework for grass leaf growth

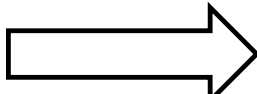


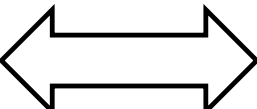
Tom De Swaef  
Mathias Cougnon  
Romain Barillot  
Jean-Louis Durand

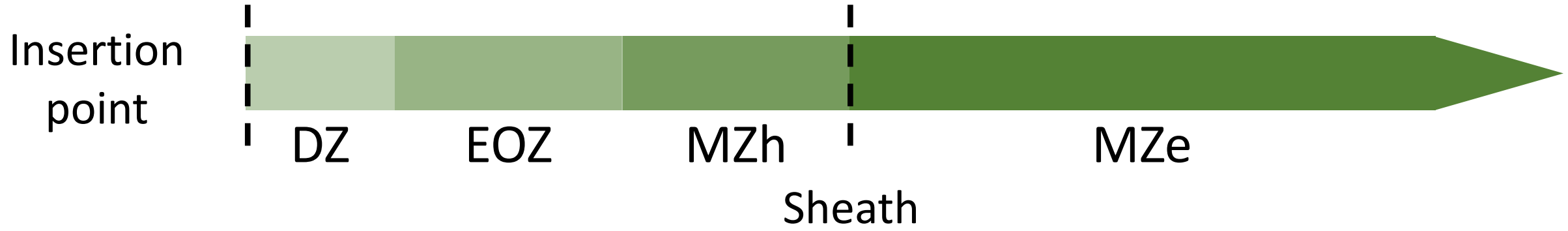
**ILVO**  
Flanders research institute for  
agriculture, fisheries and food

**INRAE**

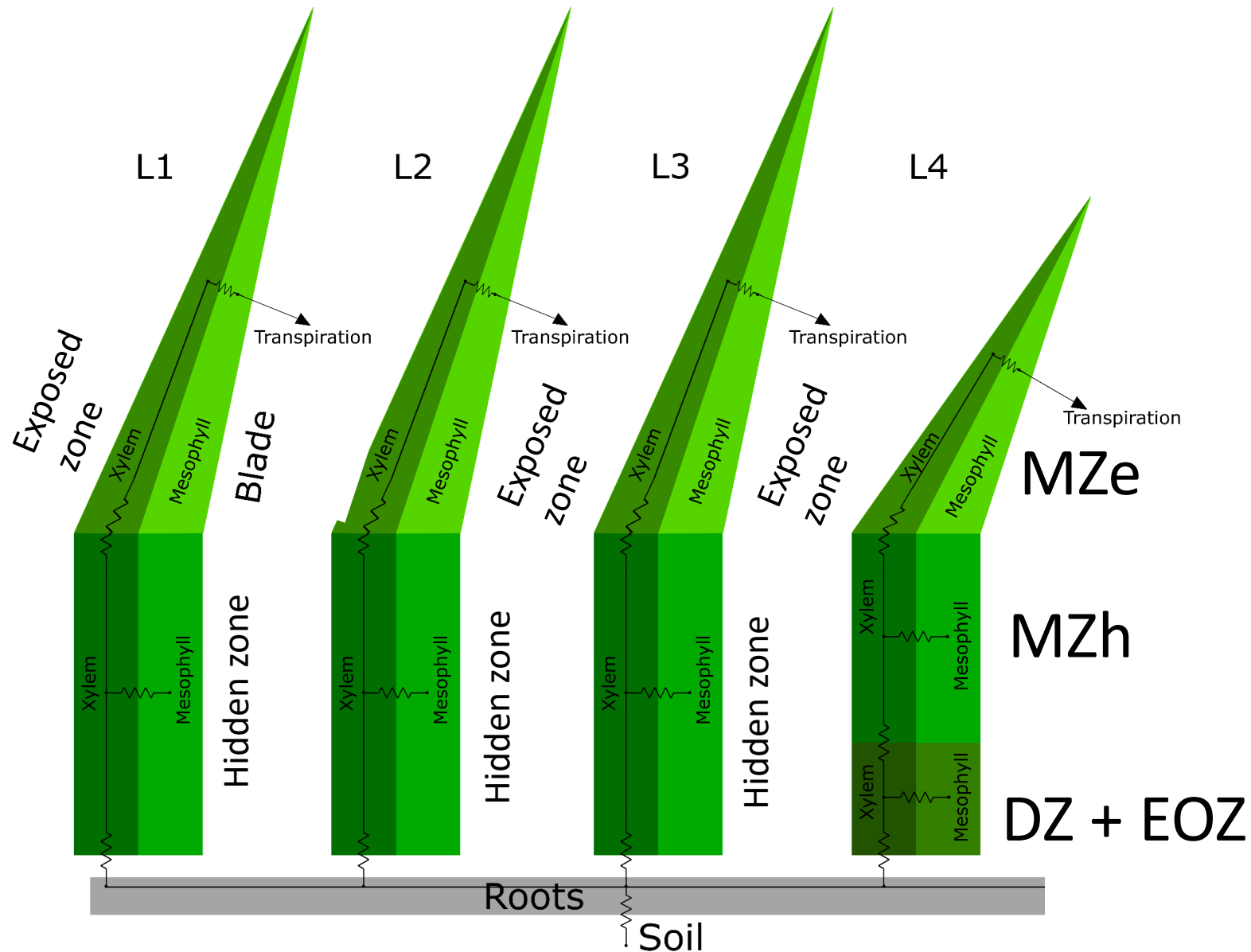


Source - sink  Harvestable plant part

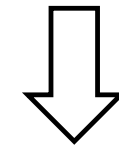
Leaf growth  Plant development



# The hydraulic model: *Festuca arundinacea*

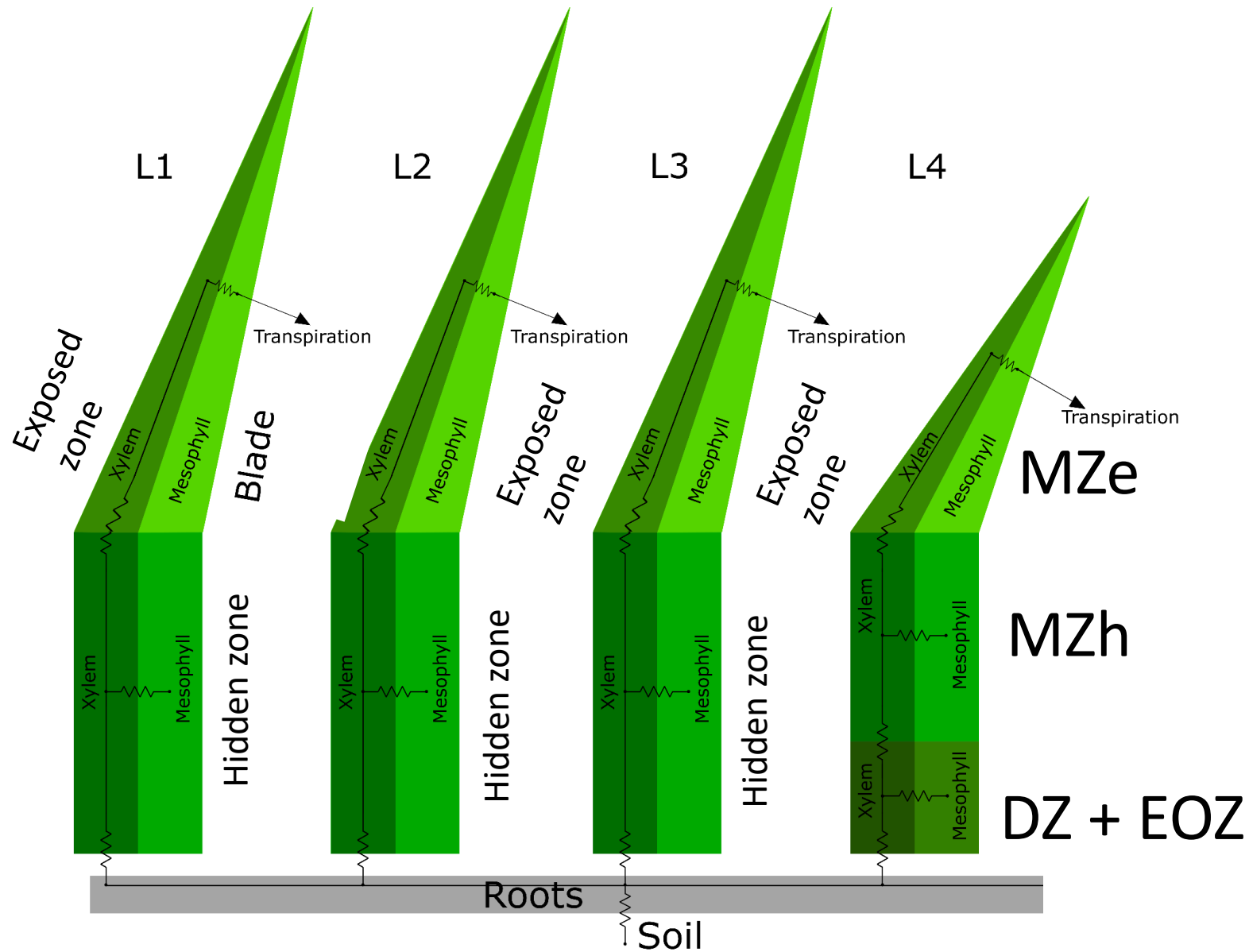


Hydraulics x Ontogeny



Growth

# The hydraulic model: *Festuca arundinacea*

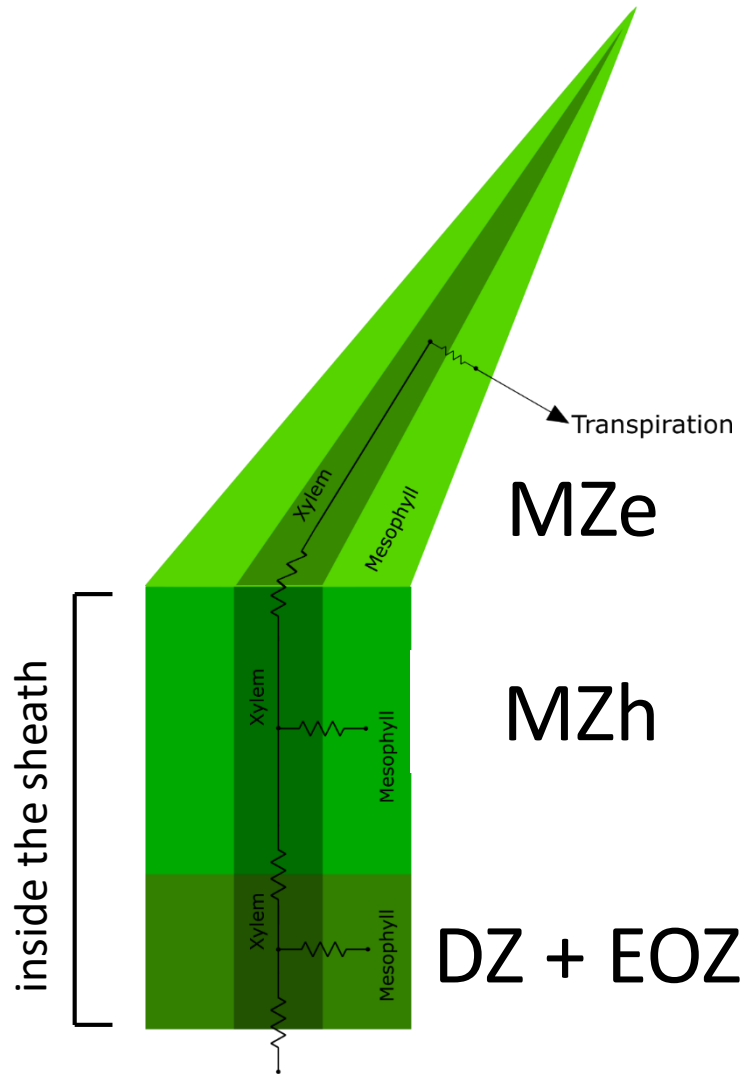


Hydraulics x Ontogeny



Growth

# The hydraulic model: hydraulic architecture



$\Psi$  Water potential  
 $\Pi$  Osmotic pressure  
 $P$  Hydrostatic pressure

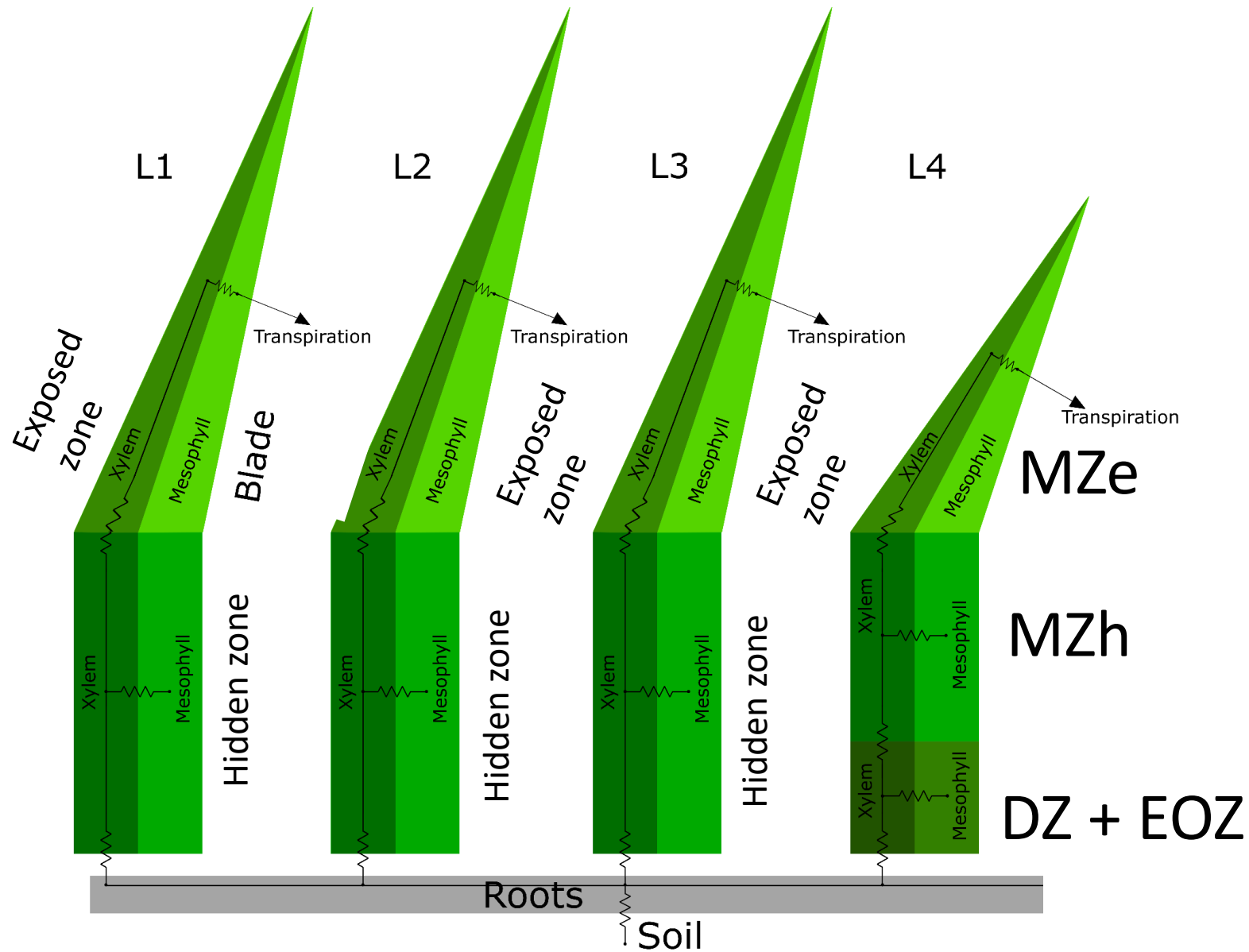
$$\Psi = P - \Pi$$

$F$  Water flow  
 $K$  Hydraulic conductance

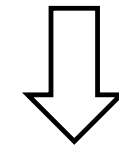
$$F = K \times \Delta\Psi$$



# The hydraulic model: *Festuca arundinacea*

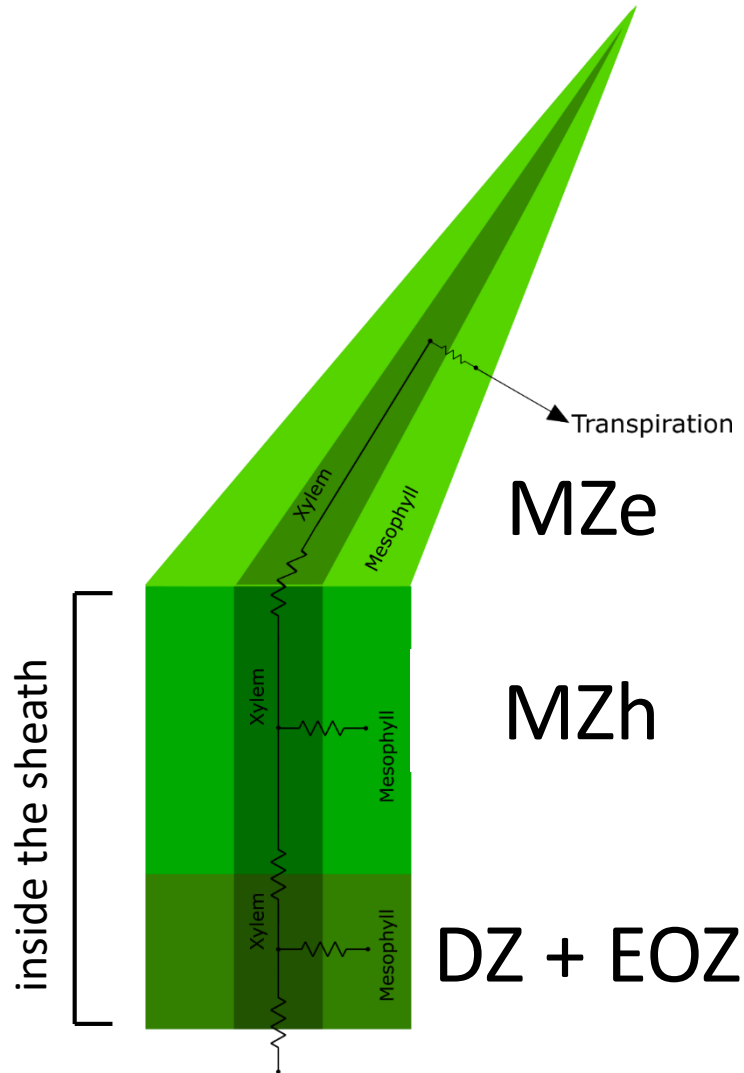


Hydraulics x Ontogeny



Growth

# The hydraulic model: mechanisms of growth



$$\frac{dW}{dt} = F_{in} - F_{out}$$

$$\frac{dP}{dt} = \frac{\varepsilon}{W} \cdot \frac{dW}{dt}$$

elastic

$$\frac{dP}{dt} = \frac{\varepsilon}{W} \cdot \frac{dW}{dt}$$

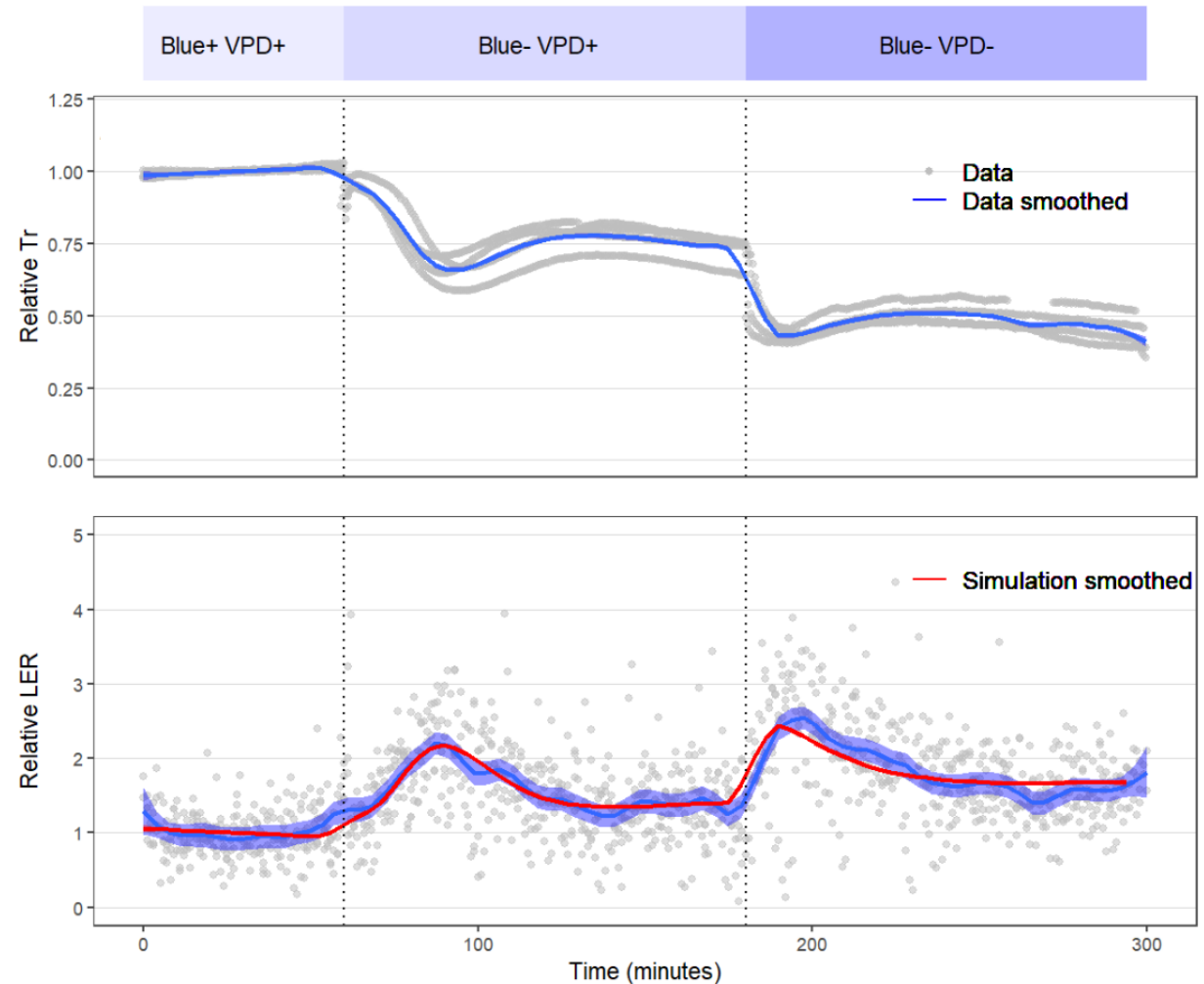
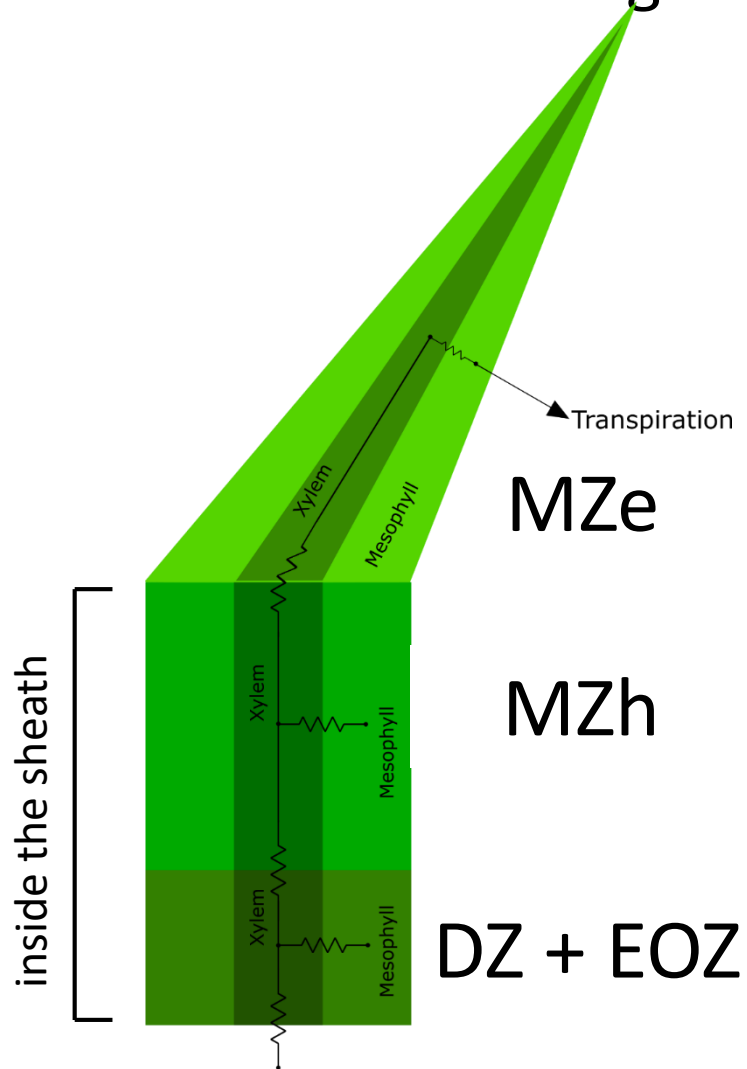
elastic

$$\frac{dP}{dt} = \frac{\varepsilon}{W} \cdot \frac{dW}{dt} - \varepsilon \cdot \phi \cdot (P - \Gamma)$$

visco-elastic

# Model to the test (1)

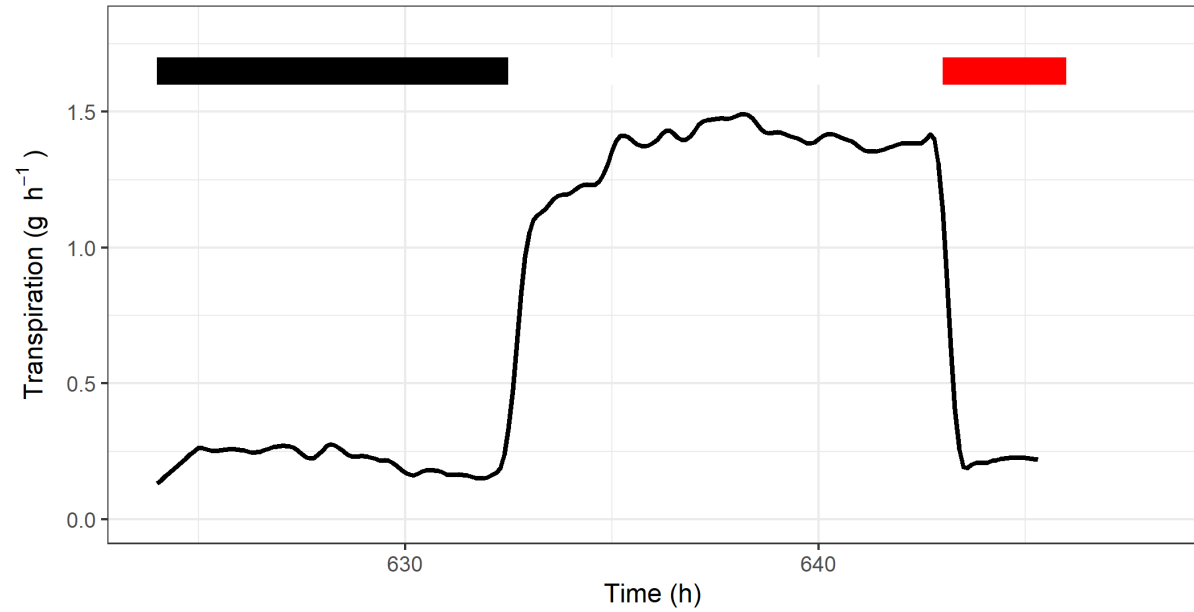
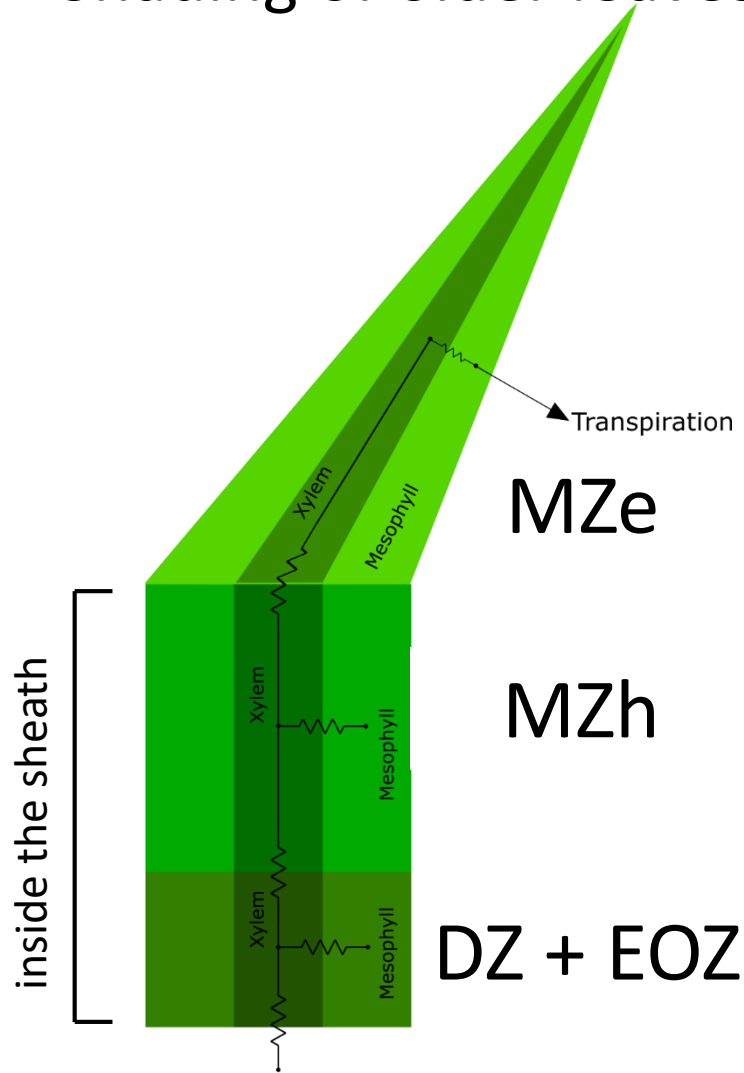
Absence of blue light increases LER



*Barillot et al. (2021)*

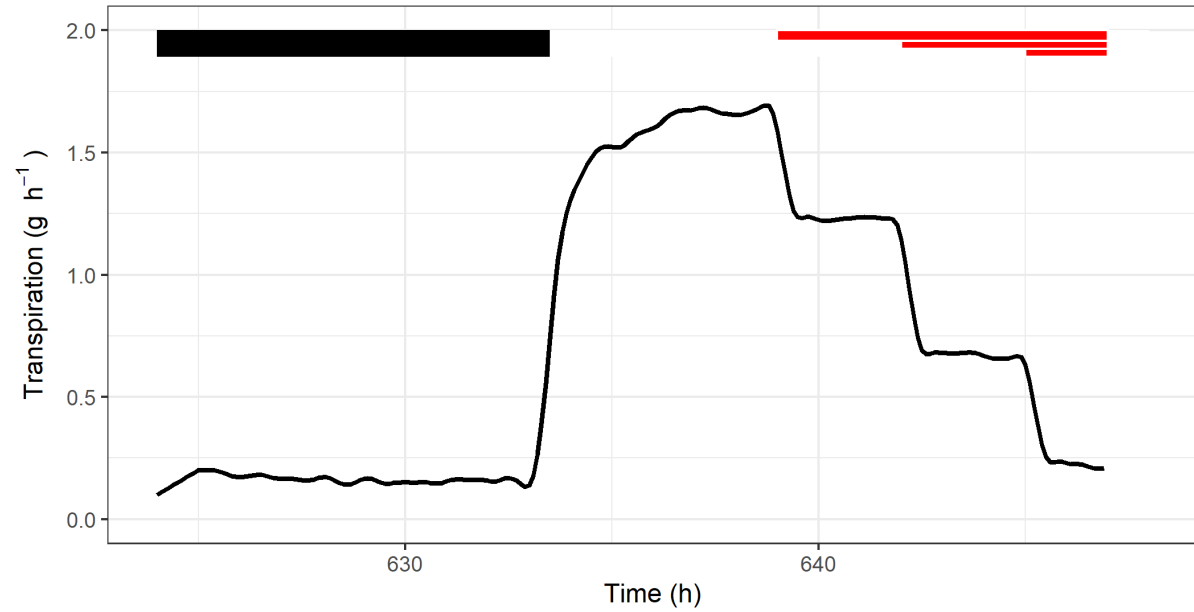
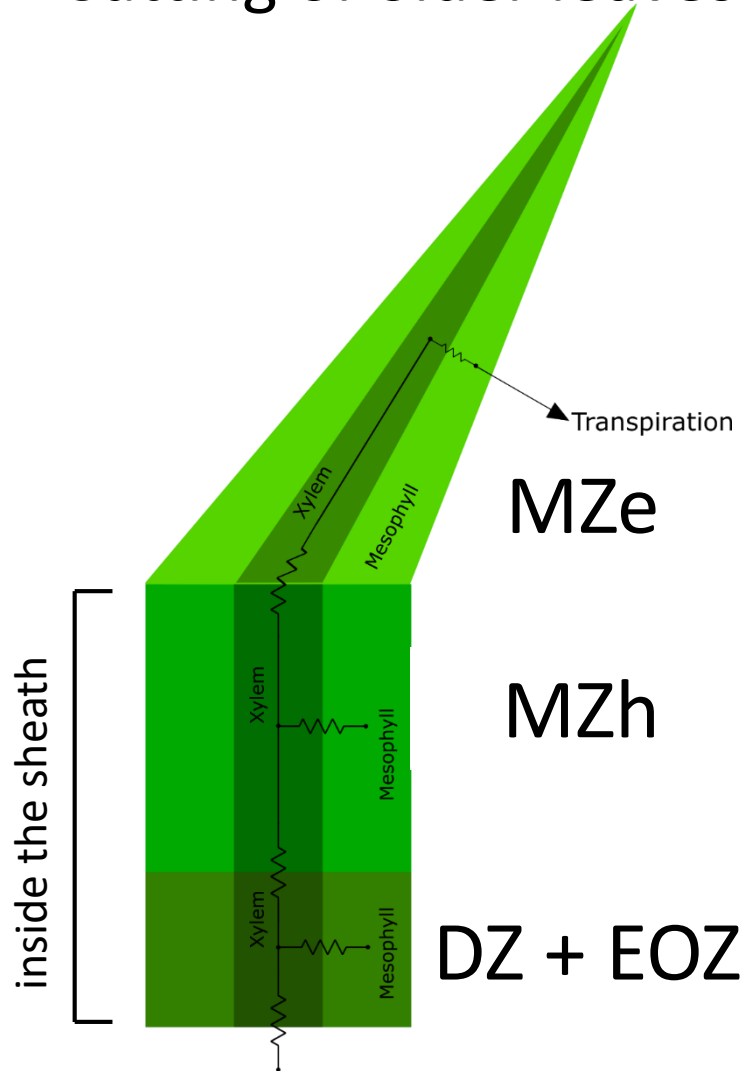
# Model to the test (2)

## Shading of older leaves

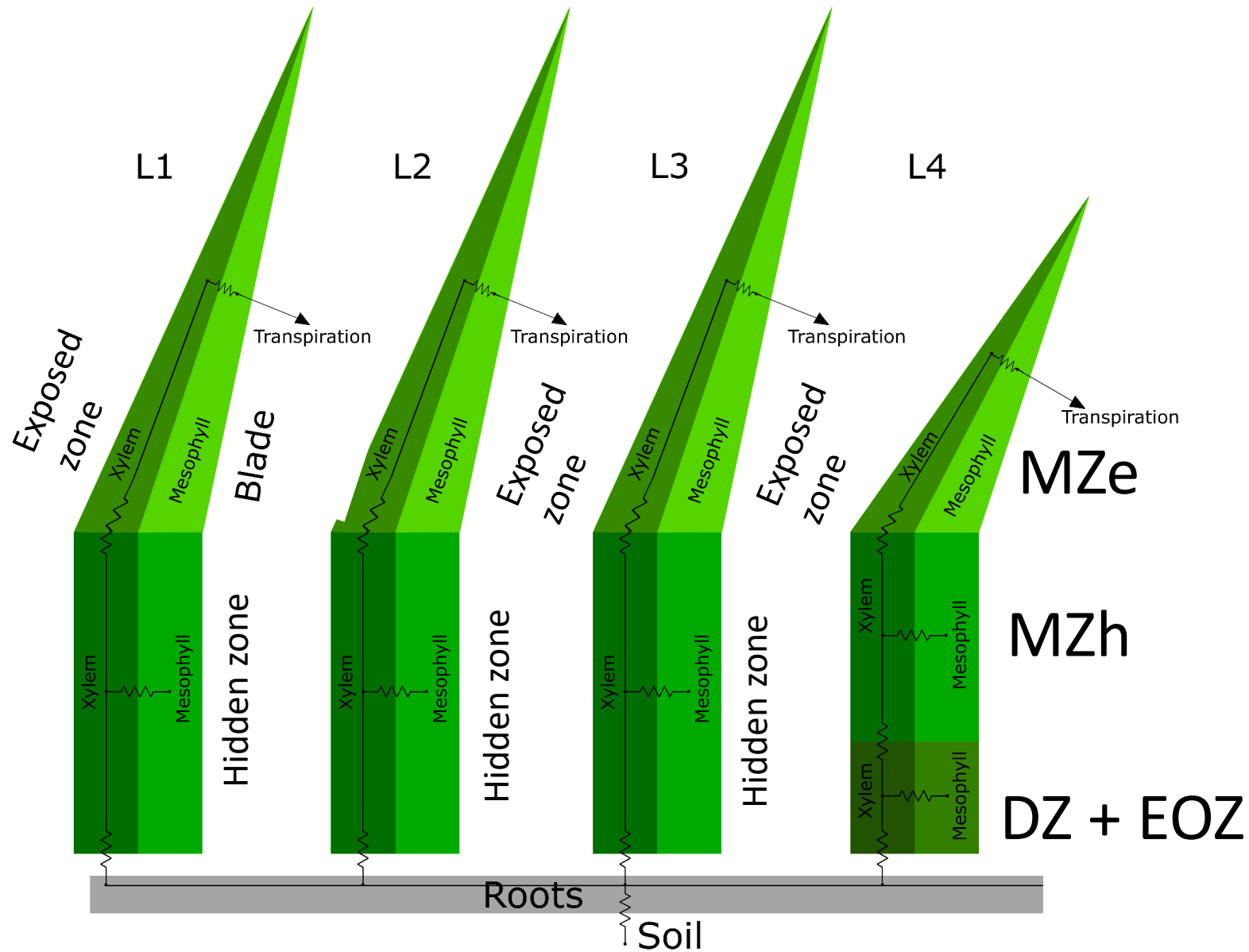


# Model to the test (3)

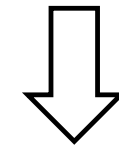
## Cutting of older leaves



# The hydraulic model: *Festuca arundinacea*

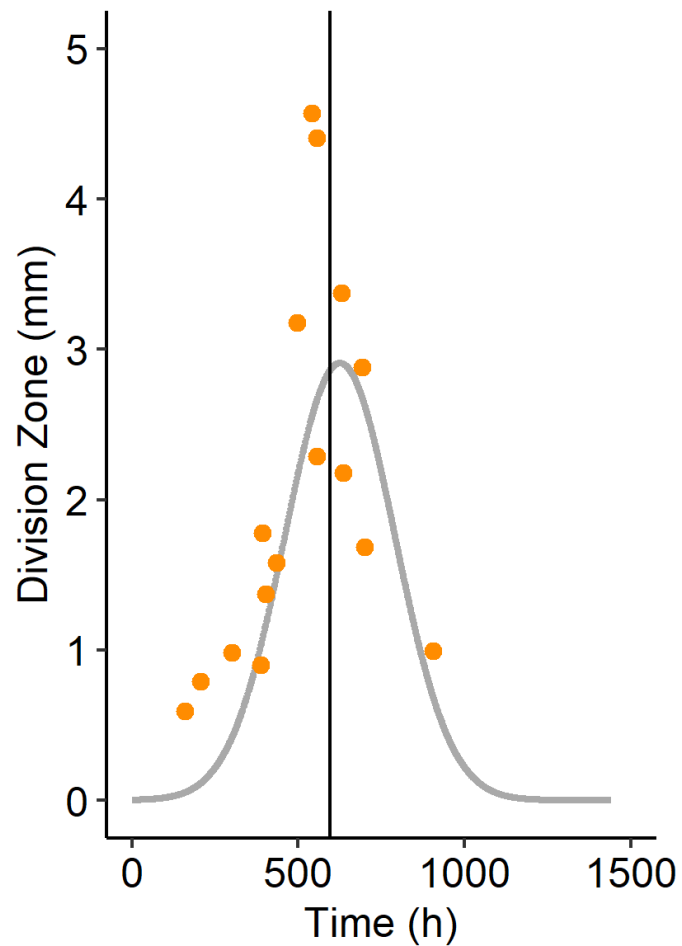


Hydraulics x Ontogeny

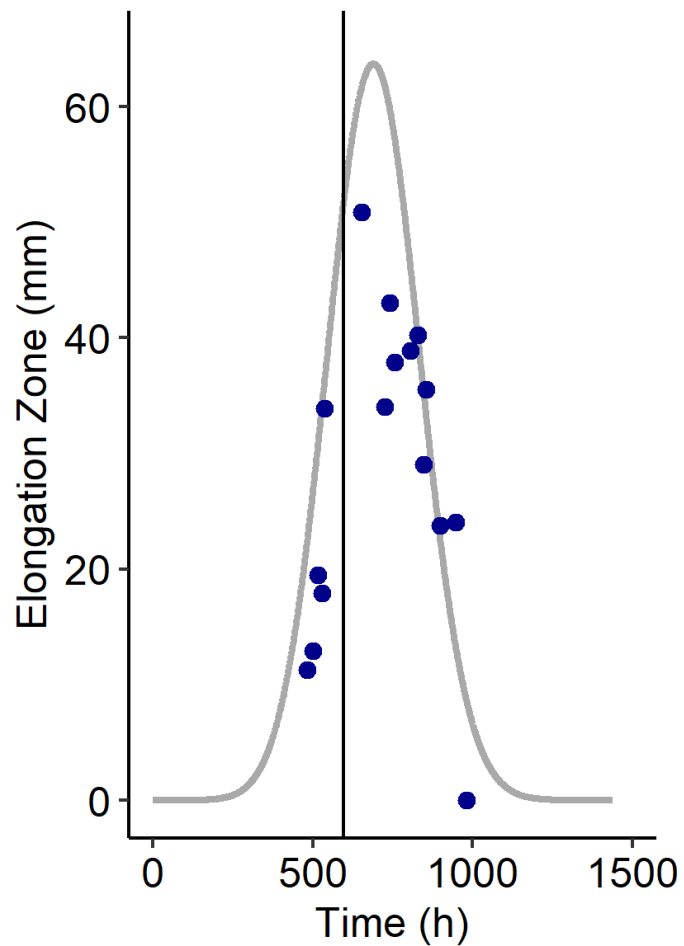


Growth

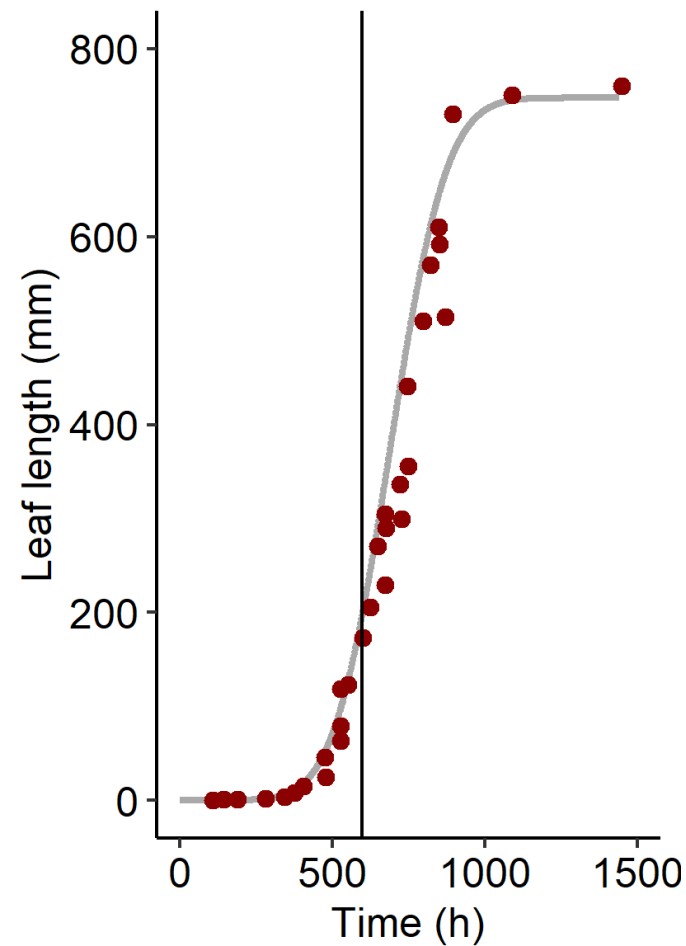
$$\frac{dDZ}{dt} = k_1(1 - a)DZ$$



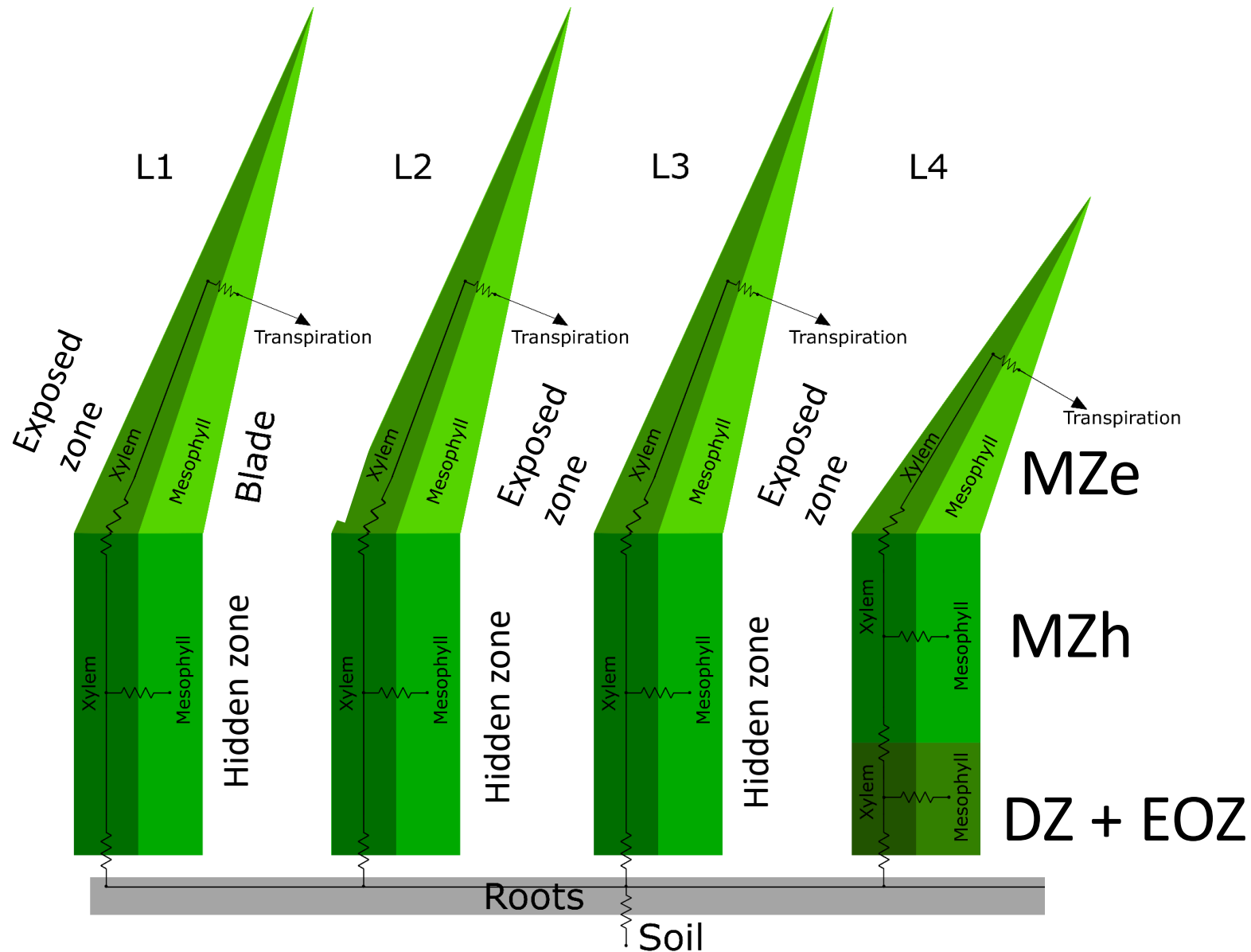
$$\frac{dEOZ}{dt} = k_1 a DZ + k_2(1 - b)EOZ$$



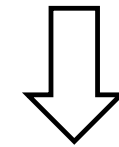
$$LER = k_1 DZ + k_2 EOZ$$



# The hydraulic model: *Festuca arundinacea*



Hydraulics x Ontogeny

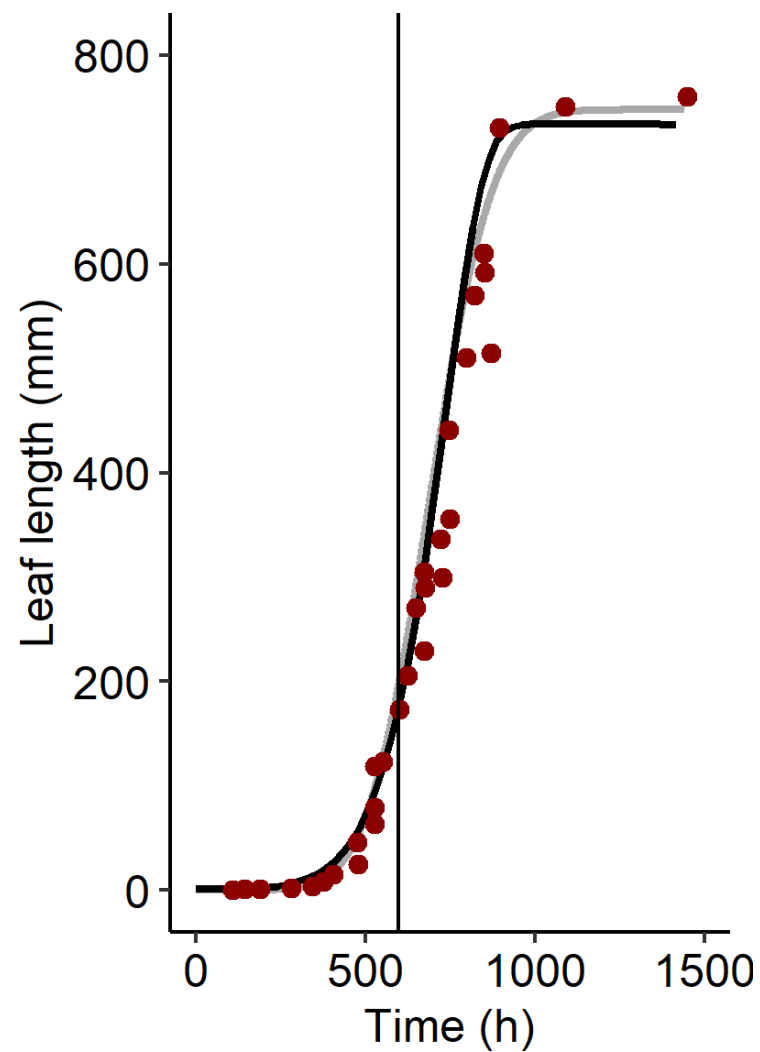
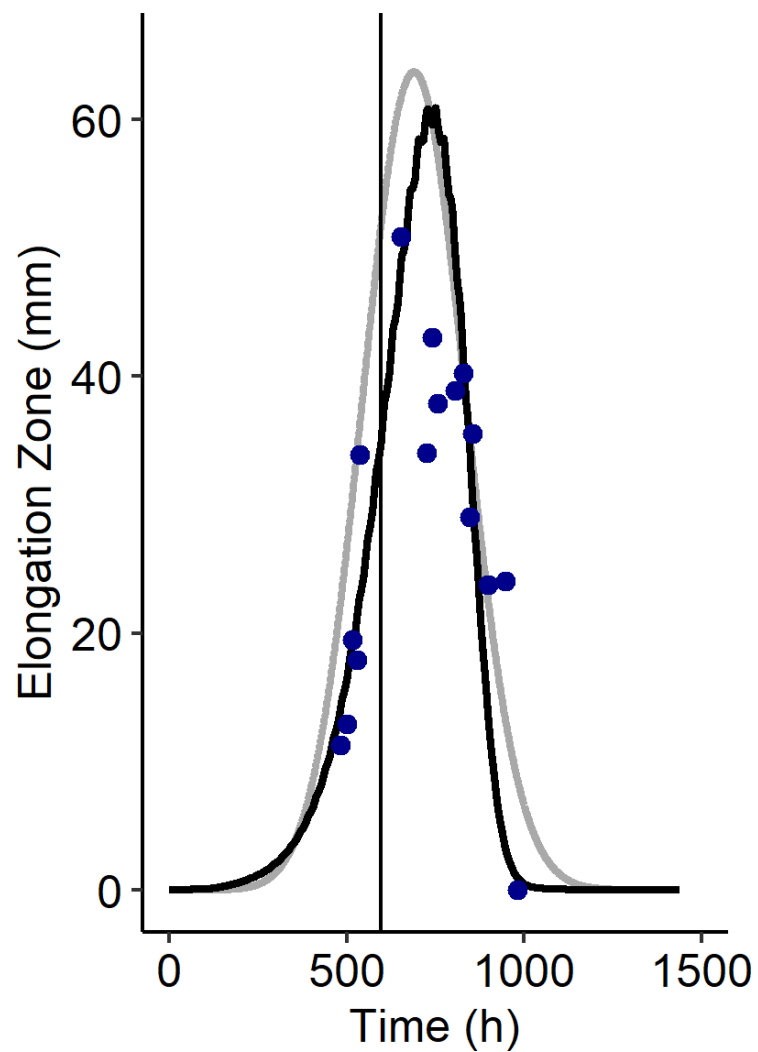
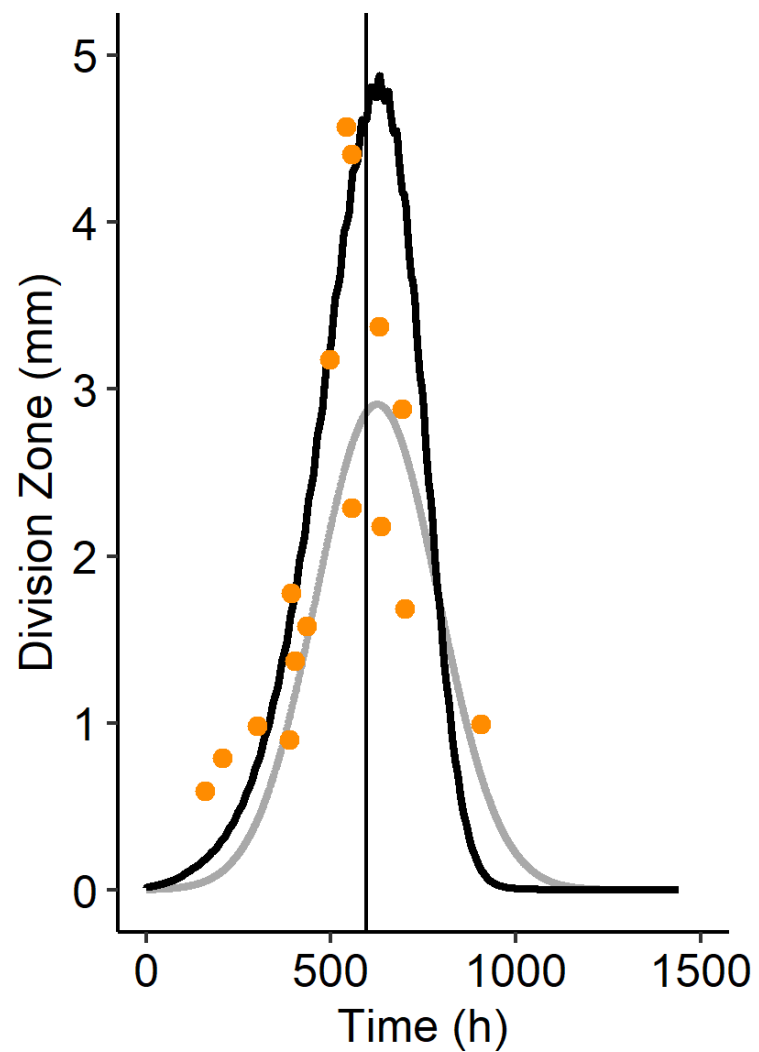


Growth

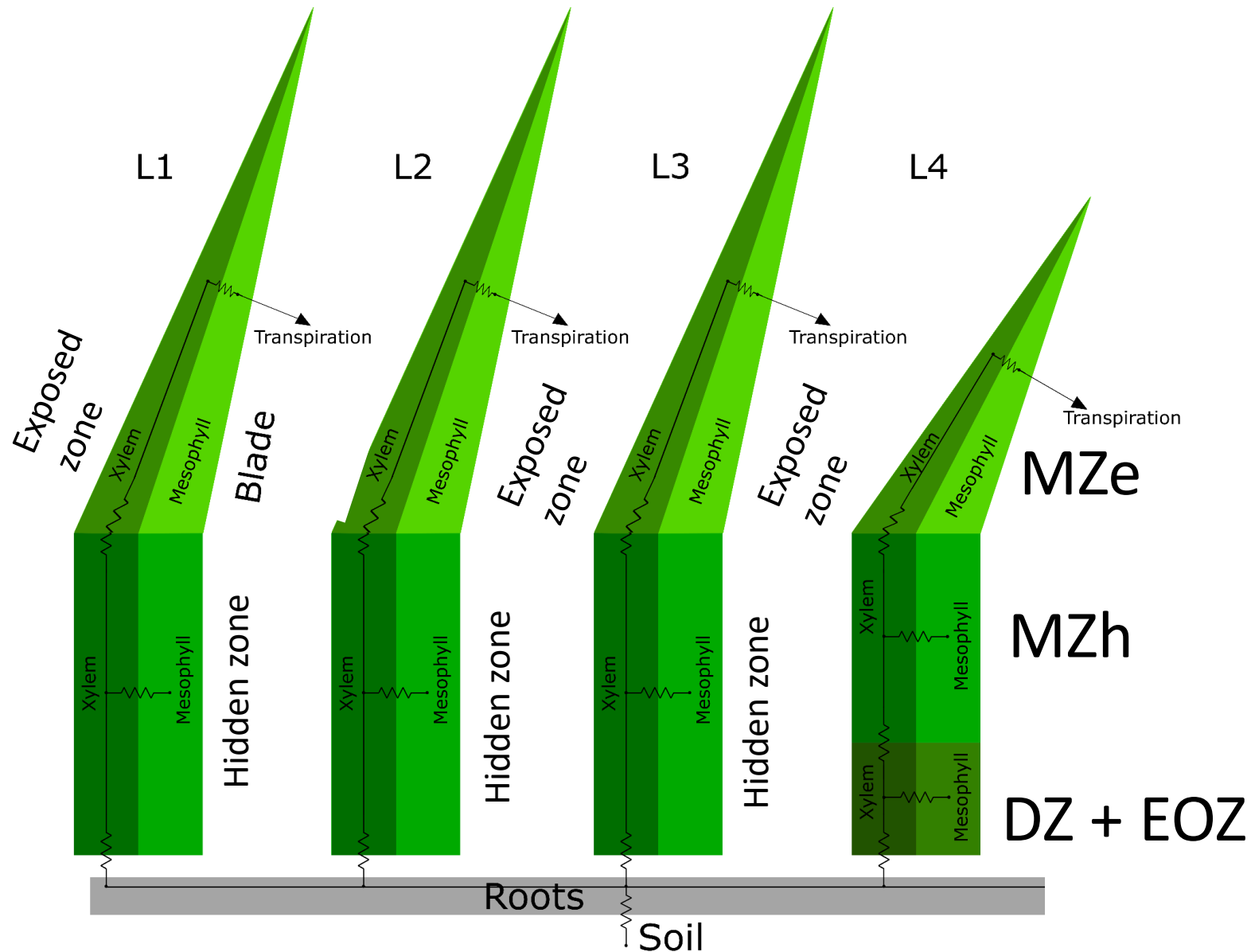


# Model ontogenic “meta-mechanism”

- Cells can only divide X times ?
- Cells grow until maximum cell length?
- At leaf emergence production of proliferative cells gradually stops



# The hydraulic model: *Festuca arundinacea*



?

Hydraulics x Ontogeny

↓

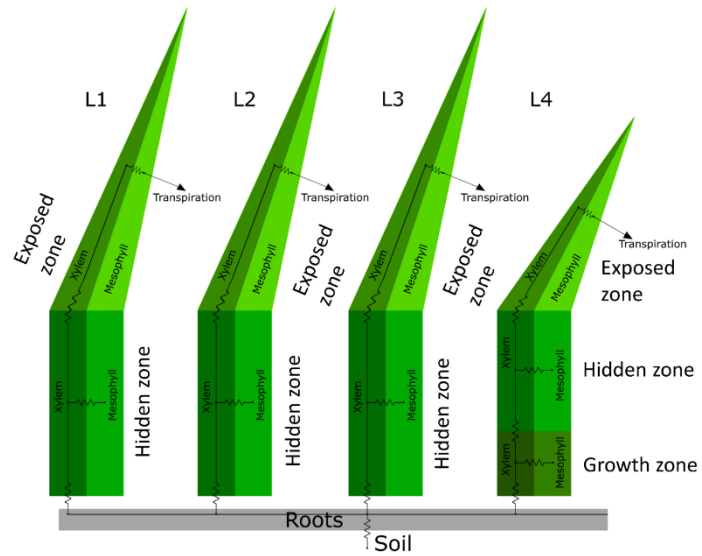
Growth

MZe  
MZh  
DZ + EOZ

# My questions to you:

- Is turgor stable in growing cells?
- Is turgor still required for growth?
  
- Is there a “stem cell”-like line at the base of growing leaves
- Cells can only divide X times ?
- Cells grow until maximum cell length?
- Is leaf emergence the cue to stop cell proliferation

# Thank you!



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