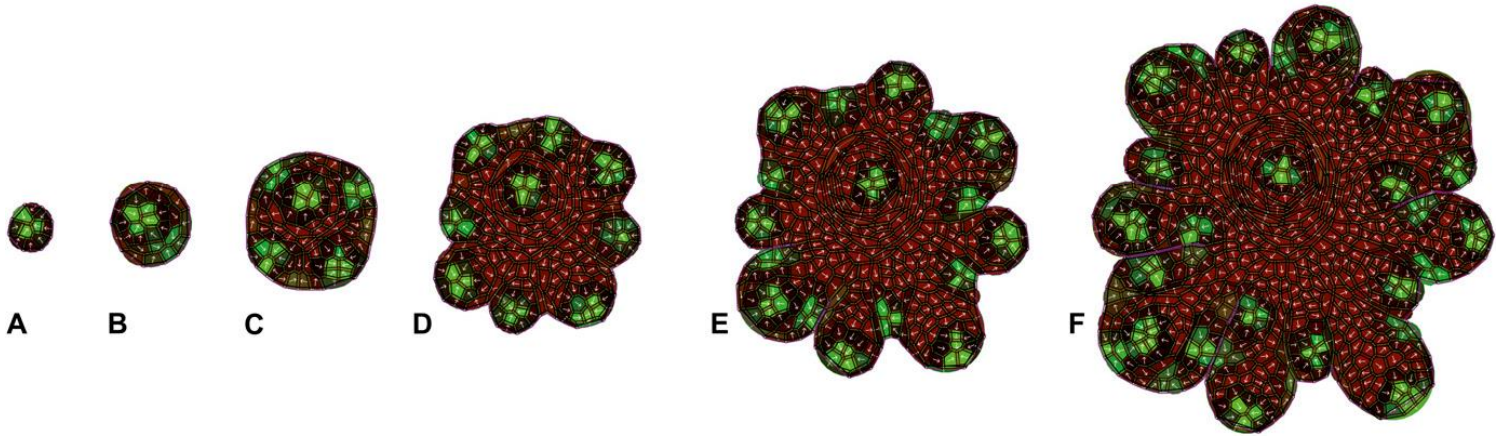
A hydraulically based model framework for the grass leaf meristem

Tom de Swaef, Mathias Cougnon, Romain Barillot, Jean-Louis Durand

Virtual Leaf

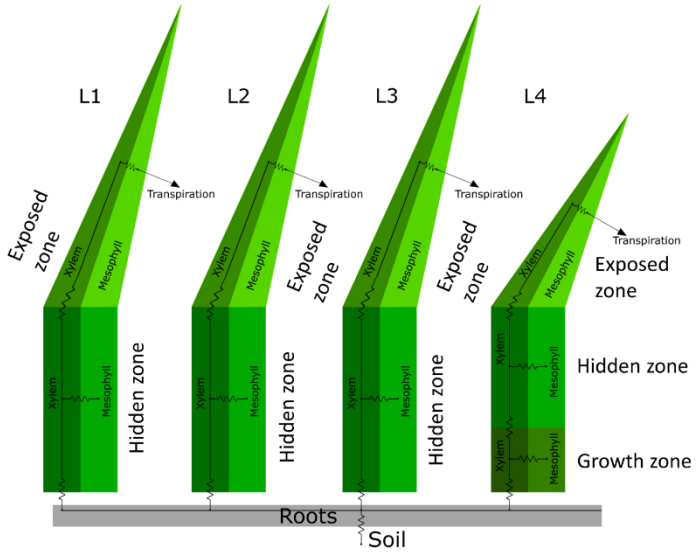
Merks et al. 2011



Virtual Plant

Coussement et al. 2020

A hydraulic model framework for grass leaf growth



Tom De Swaef
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Romain Barillot
Jean-Louis Durand

ILVO
Flanders research institute for agriculture, fisheries and food

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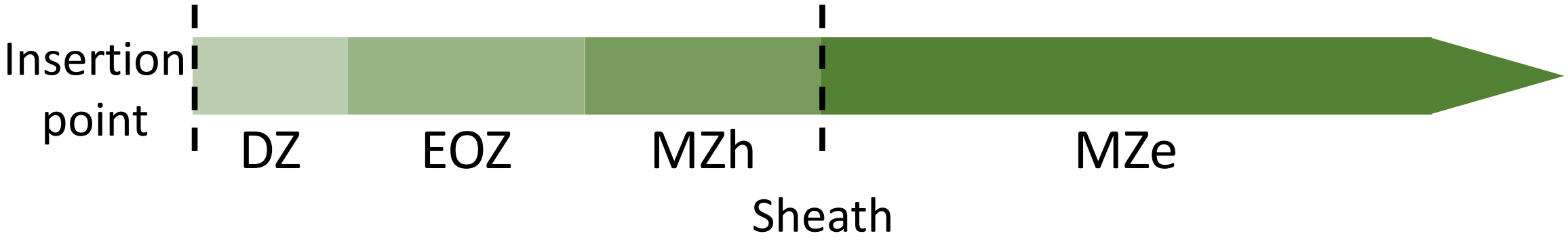
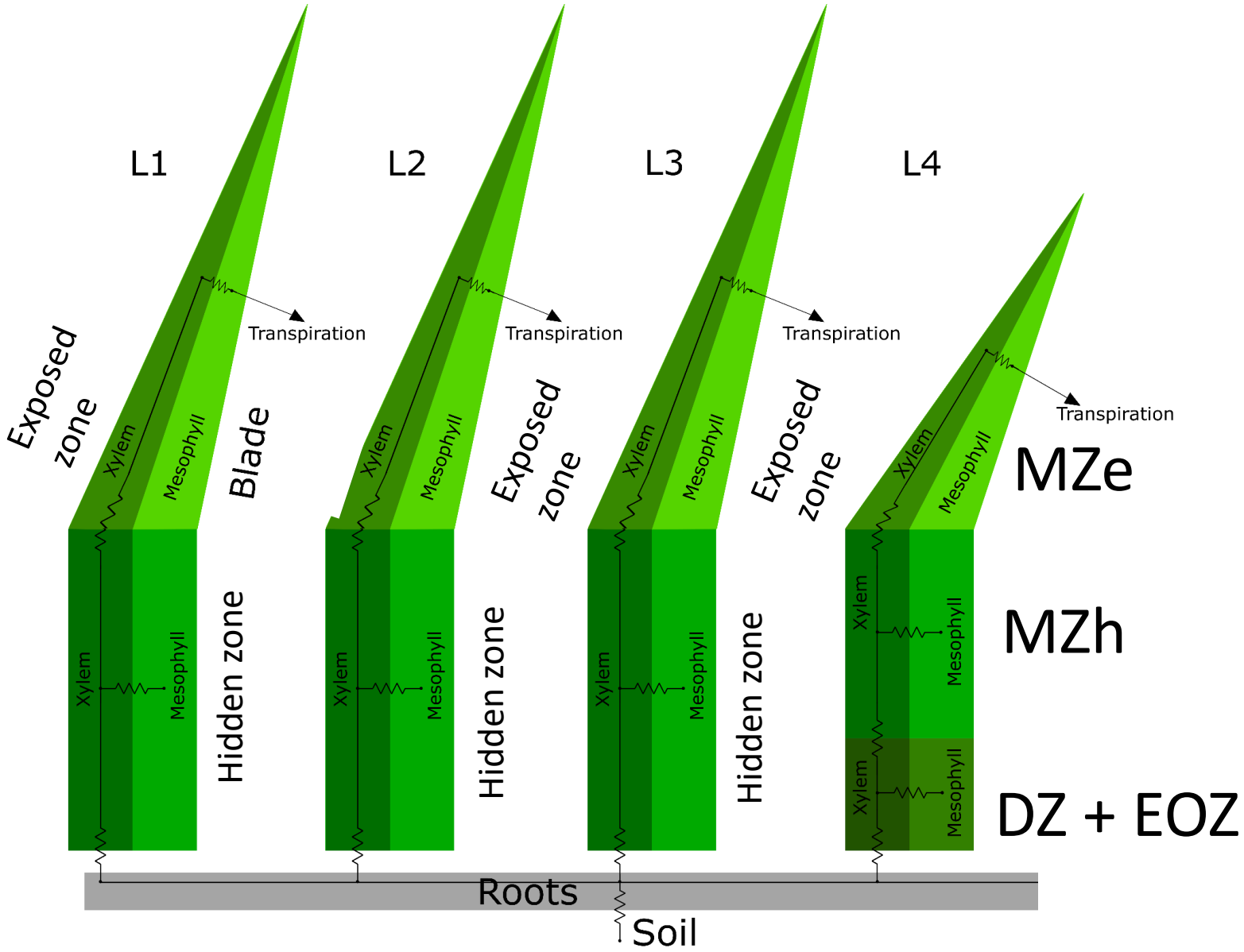


Source - sink ⇒ Harvestable plant part

Leaf growth ⇔ Plant development


Insertion point
DZ
EOZ
MZh
MZe
Sheath
Cell division
Cell growth
Elasticity
Transpiration

The hydraulic model: *Festuca arundinacea*

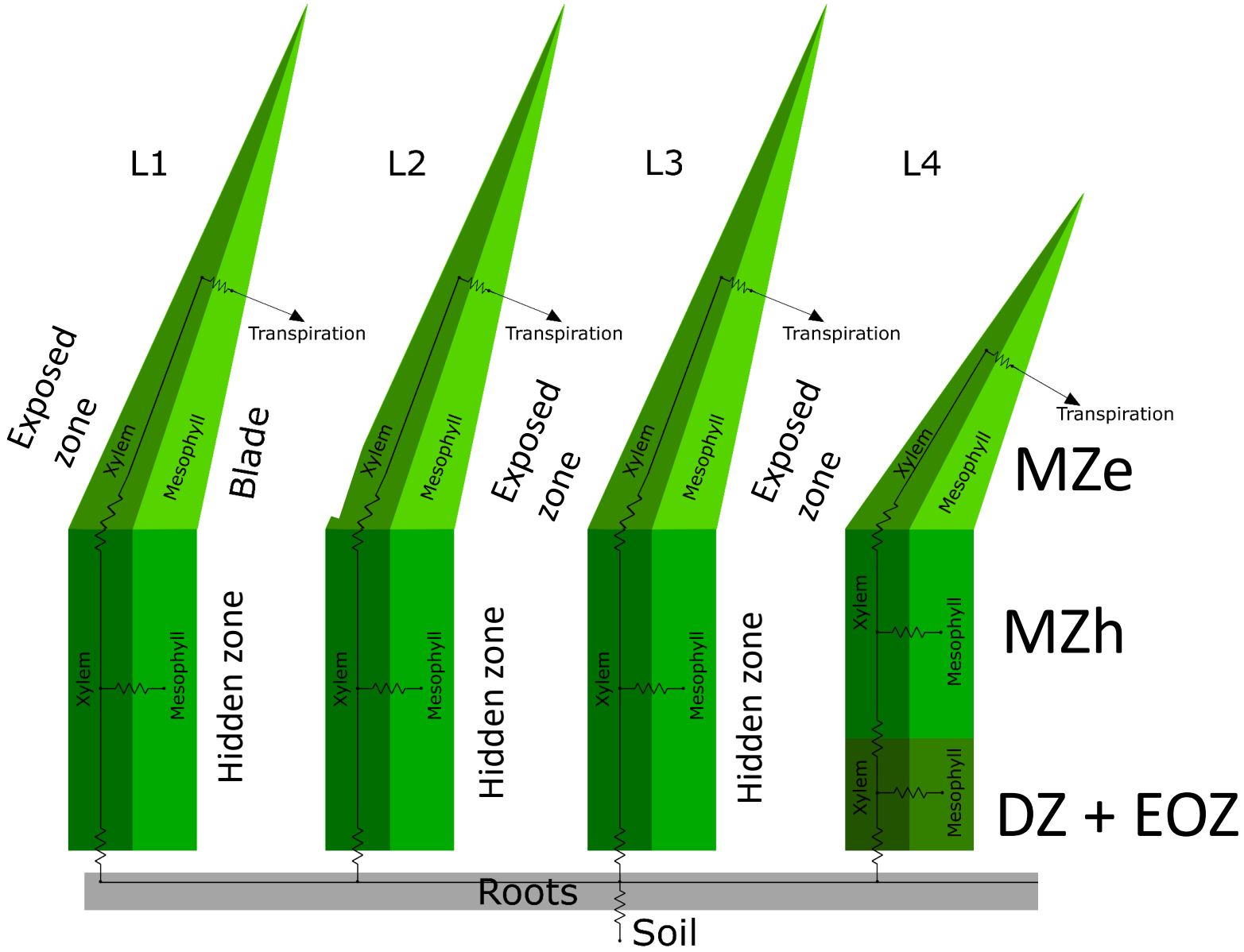


Hydraulics x Ontogeny

⇩

Growth

The hydraulic model: *Festuca arundinacea*



Hydraulics x Ontogeny

⇩

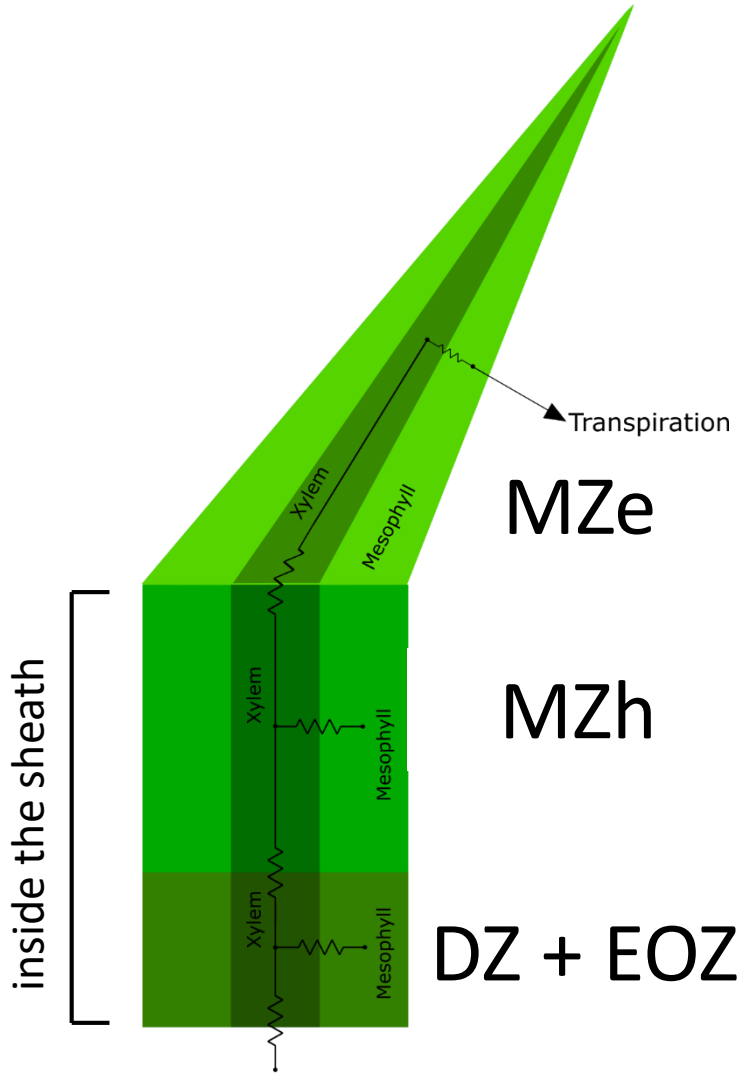
Growth

MZe

MZh

DZ + EOZ

The hydraulic model: hydraulic architecture



MZe

MZh

DZ + EOZ

Ψ	Water potential
Π	Osmotic pressure
P	Hydrostatic pressure

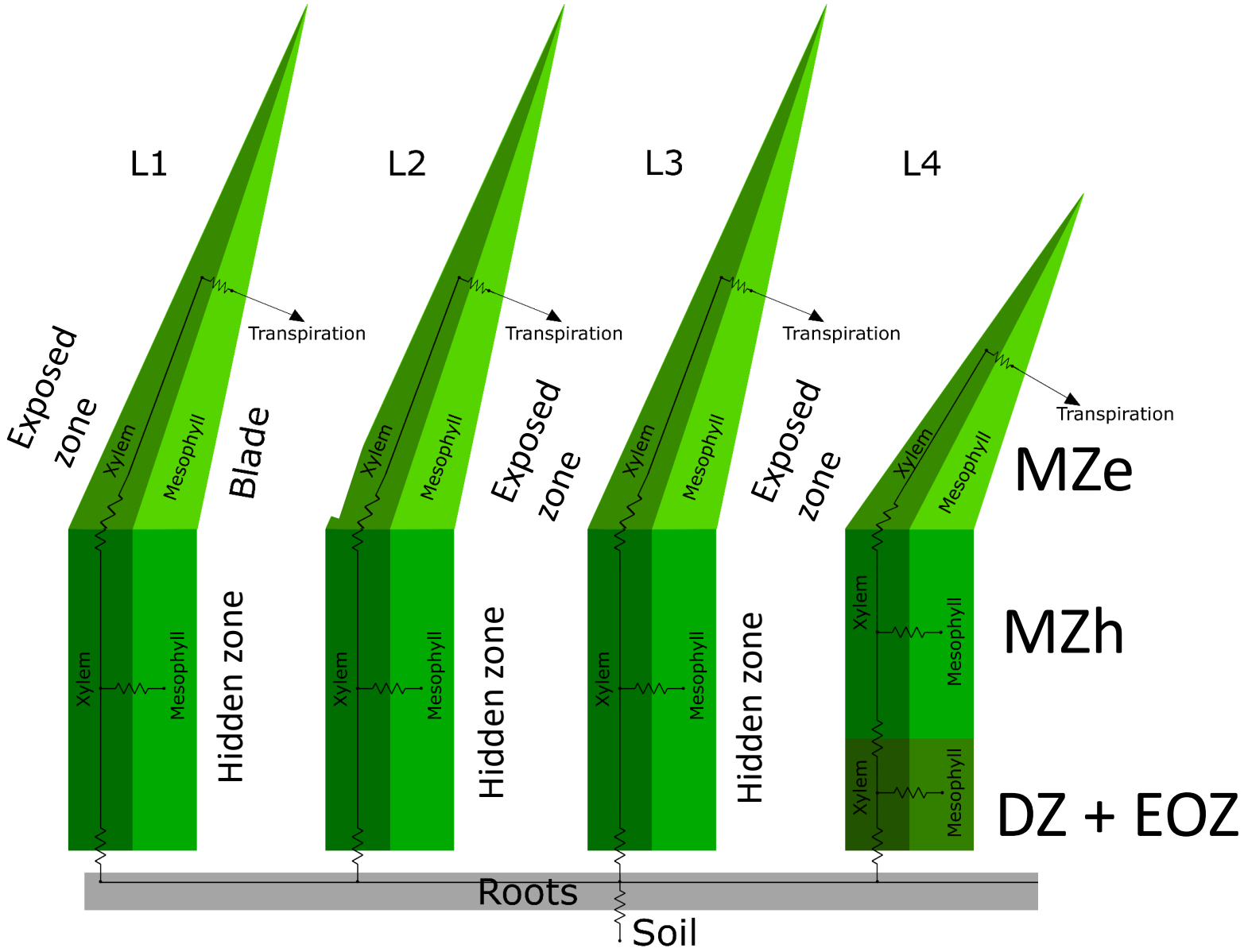
$$\Psi = P - \Pi$$

F	Water flow
K	Hydraulic conductance

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

Barillot et al. 2021

The hydraulic model: *Festuca arundinacea*

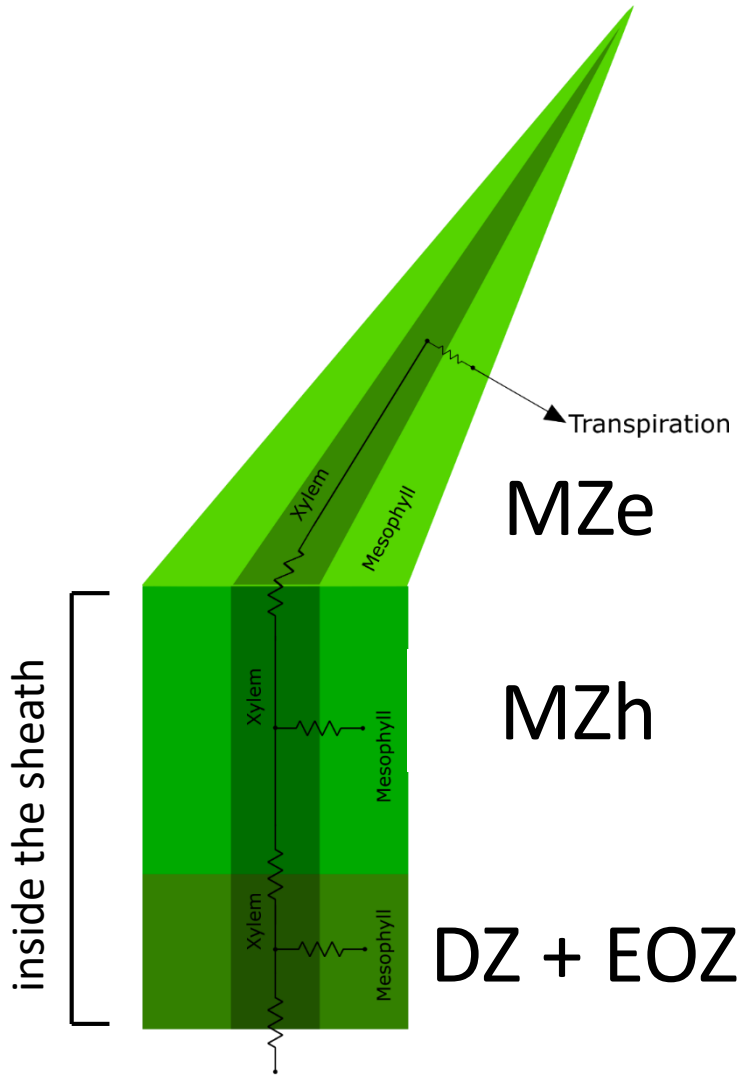


Hydraulics x Ontogeny

⇩

Growth

The hydraulic model: mechanisms of growth



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

MZe

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

elastic

MZh

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

elastic

DZ + EOZ

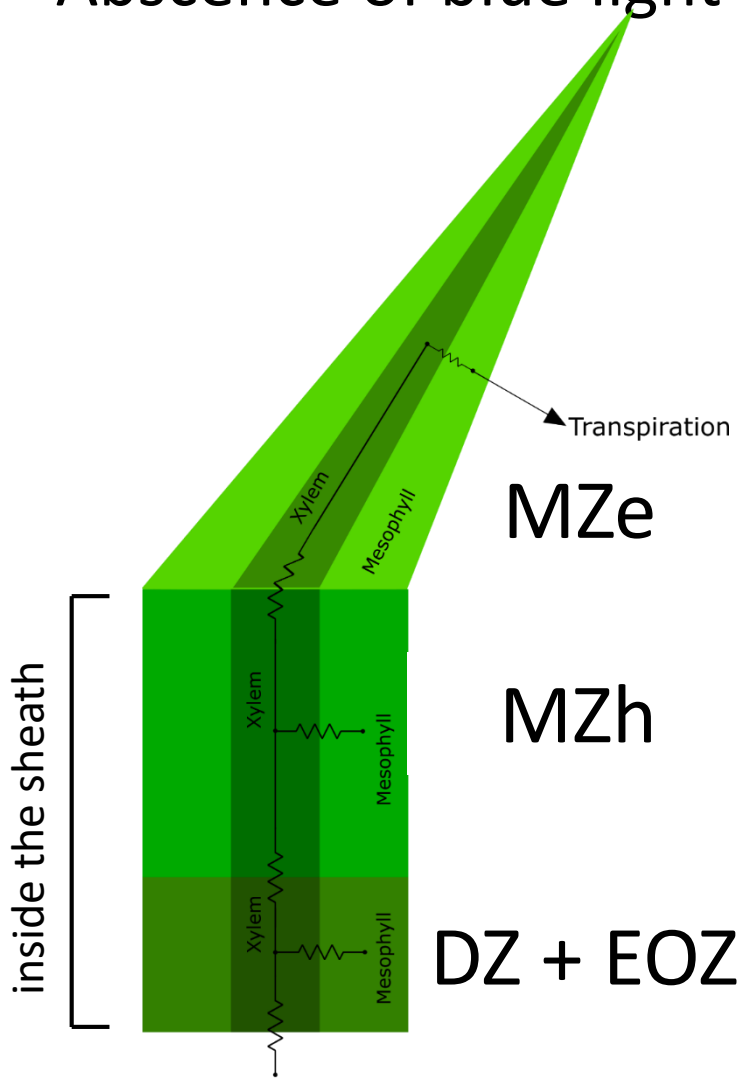
$$\frac{dP}{dt} = \frac{\varepsilon}{W} \cdot \frac{dW}{dt} - \varepsilon \cdot \phi \cdot (P - \Gamma)$$

visco-elastic

Ortega 1985
Barillot et al. 2021

Model to the test (1)

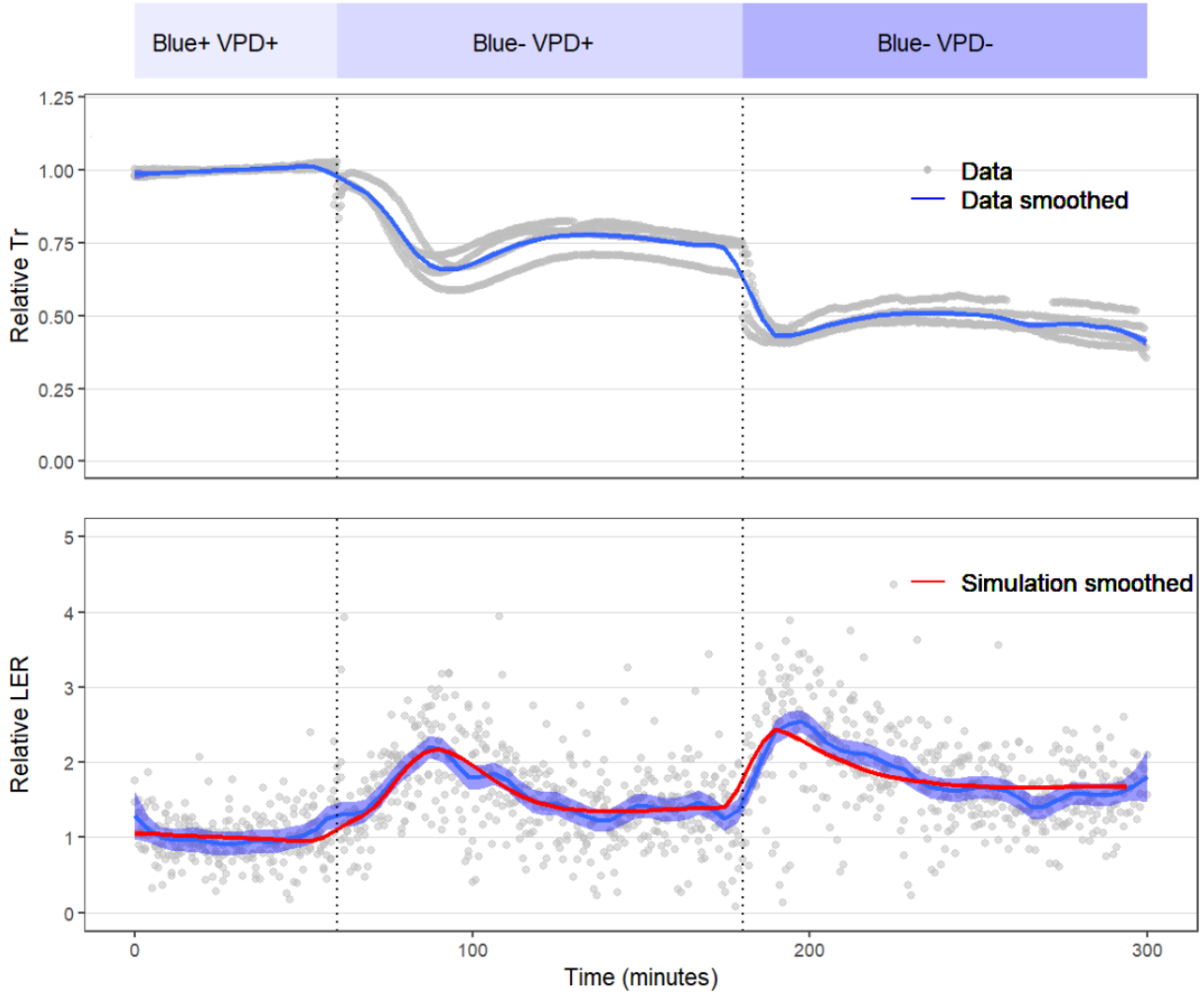
Abscence of blue light increases LER



MZe

MZh

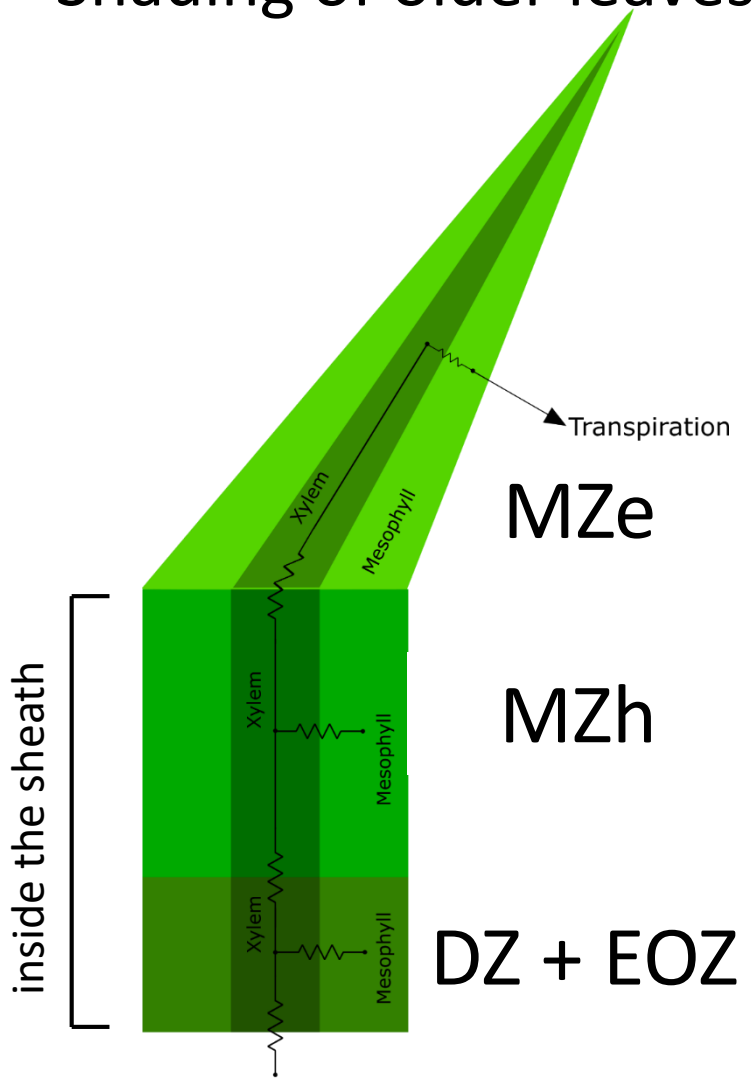
DZ + EOZ



Barillot et al. (2021)

Model to the test (2)

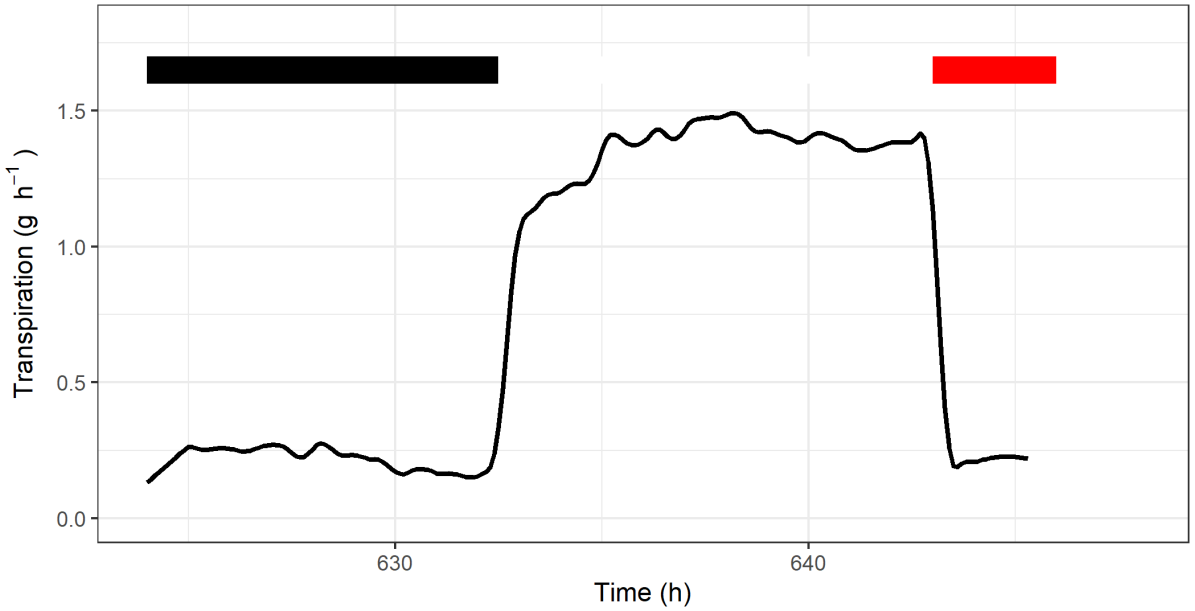
Shading of older leaves



MZe

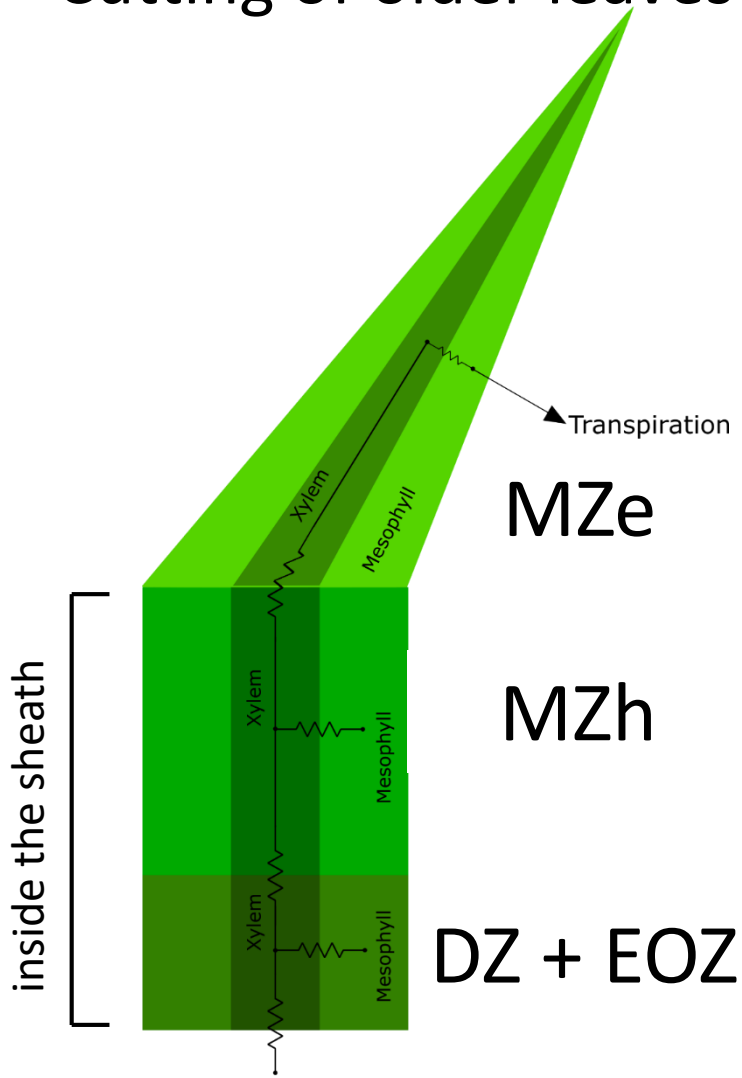
MZh

DZ + EOZ



Model to the test (3)

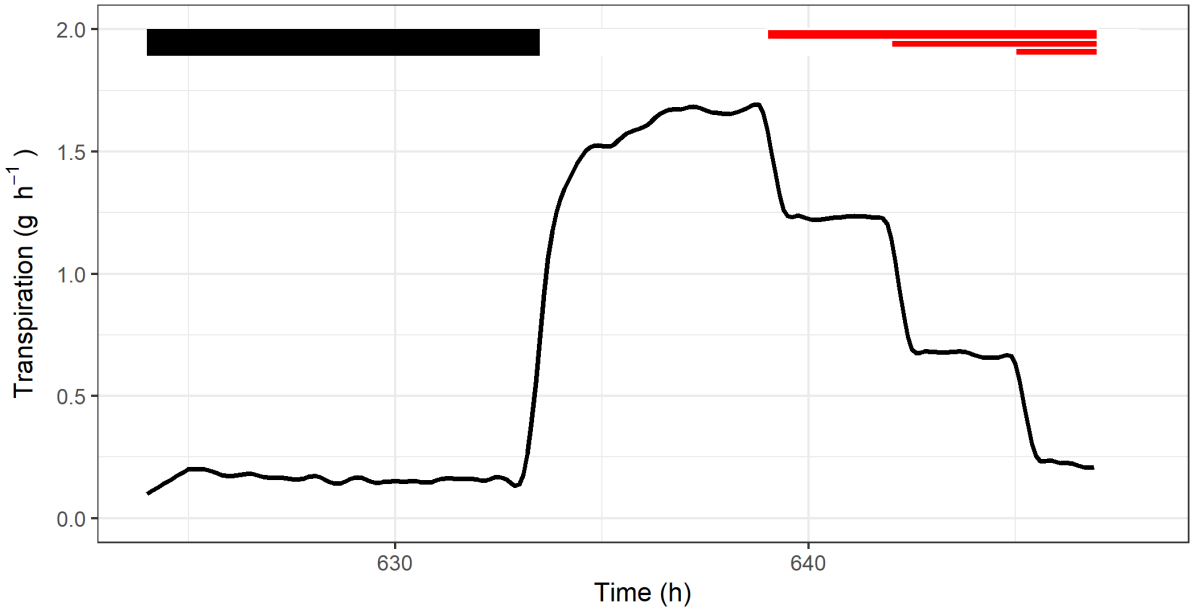
Cutting of older leaves



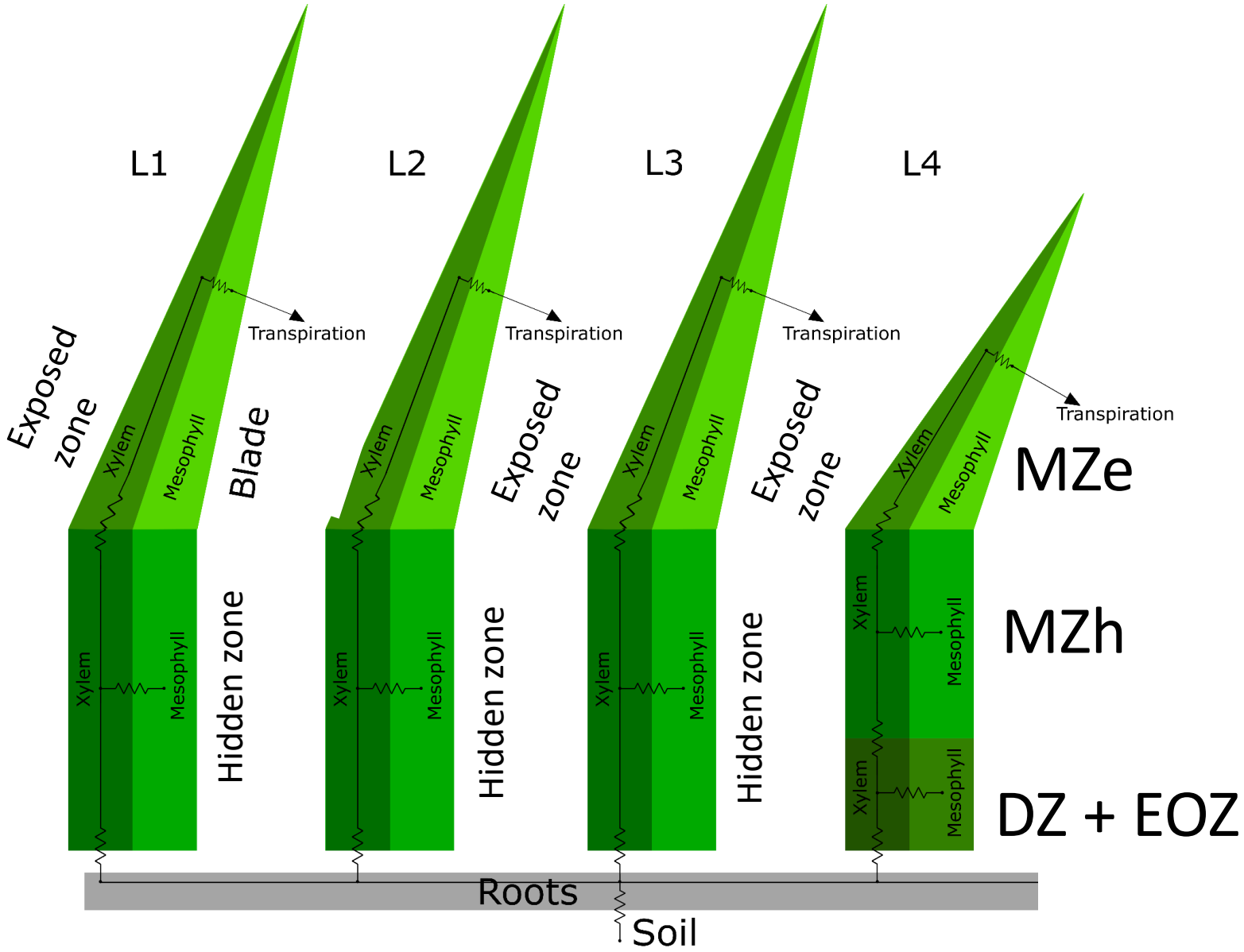
MZe

MZh

DZ + EOZ



The hydraulic model: *Festuca arundinacea*



Hydraulics x Ontogeny

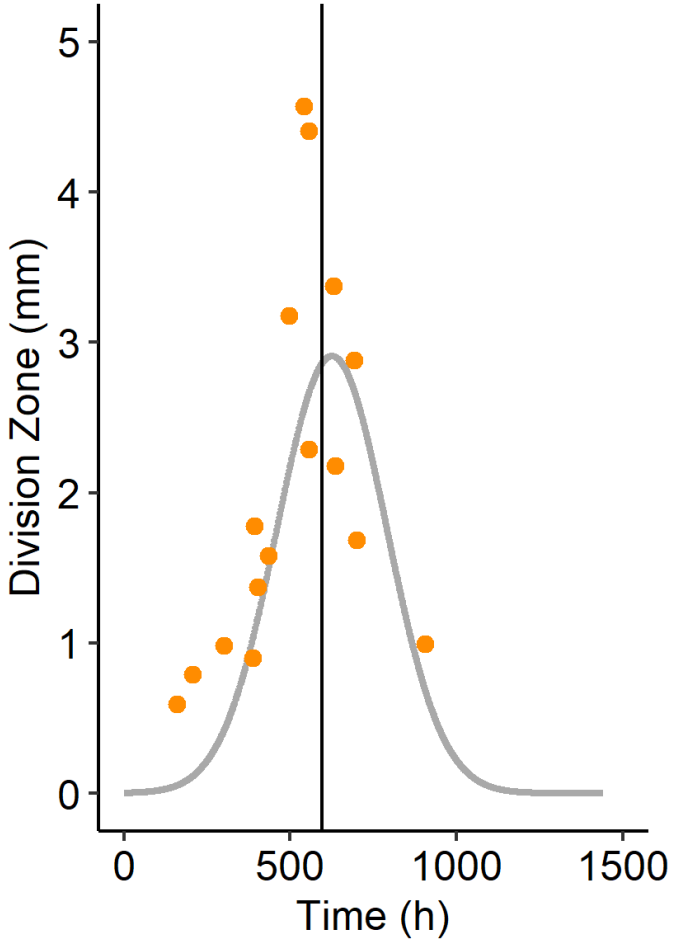
⇩

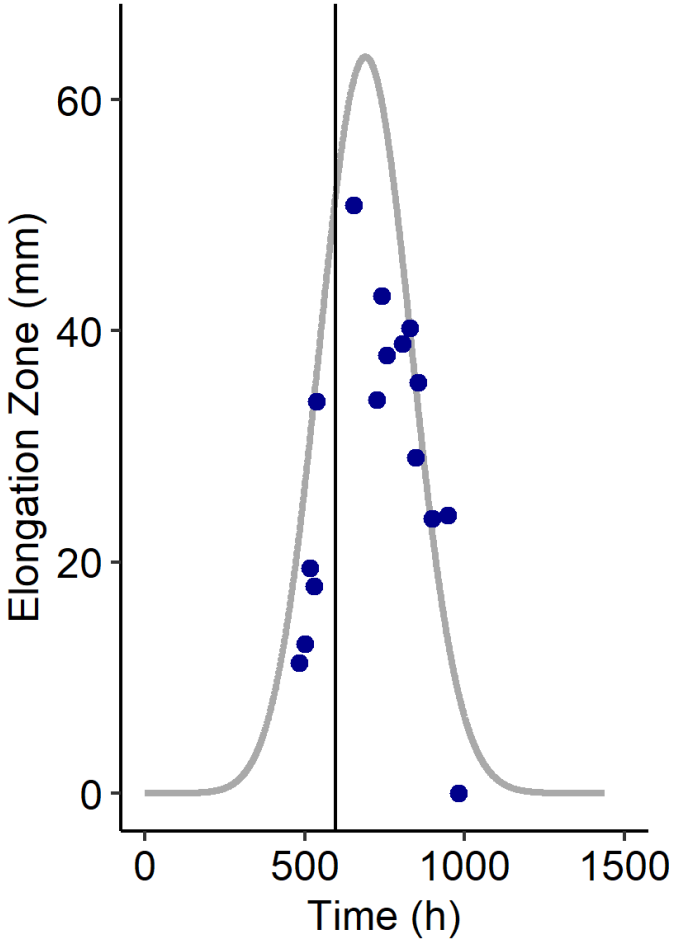
Growth

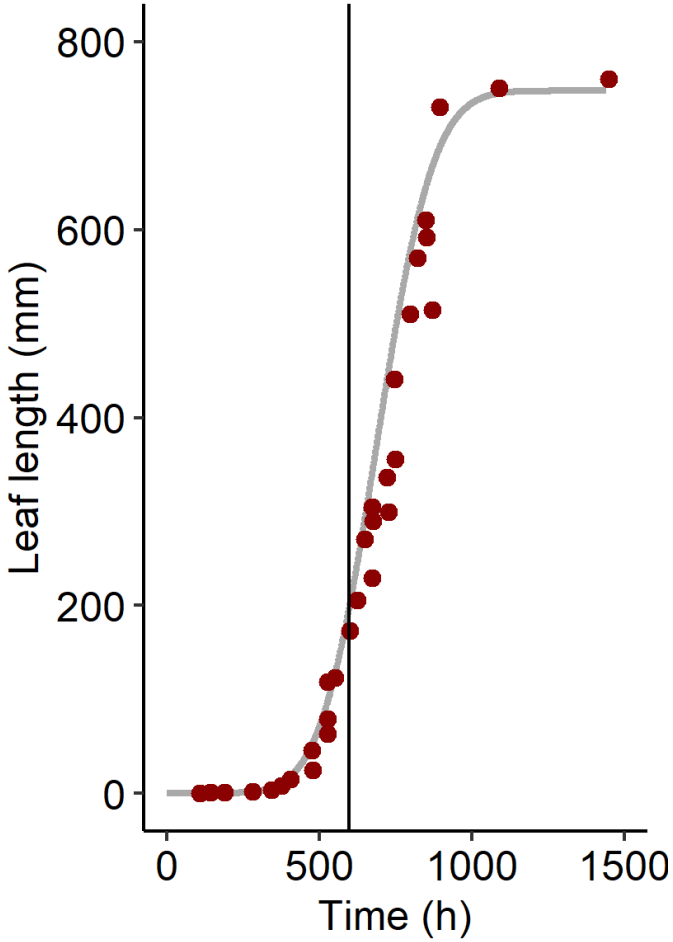
$$\frac{dDZ}{dt} = k_1(1-a)DZ$$

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

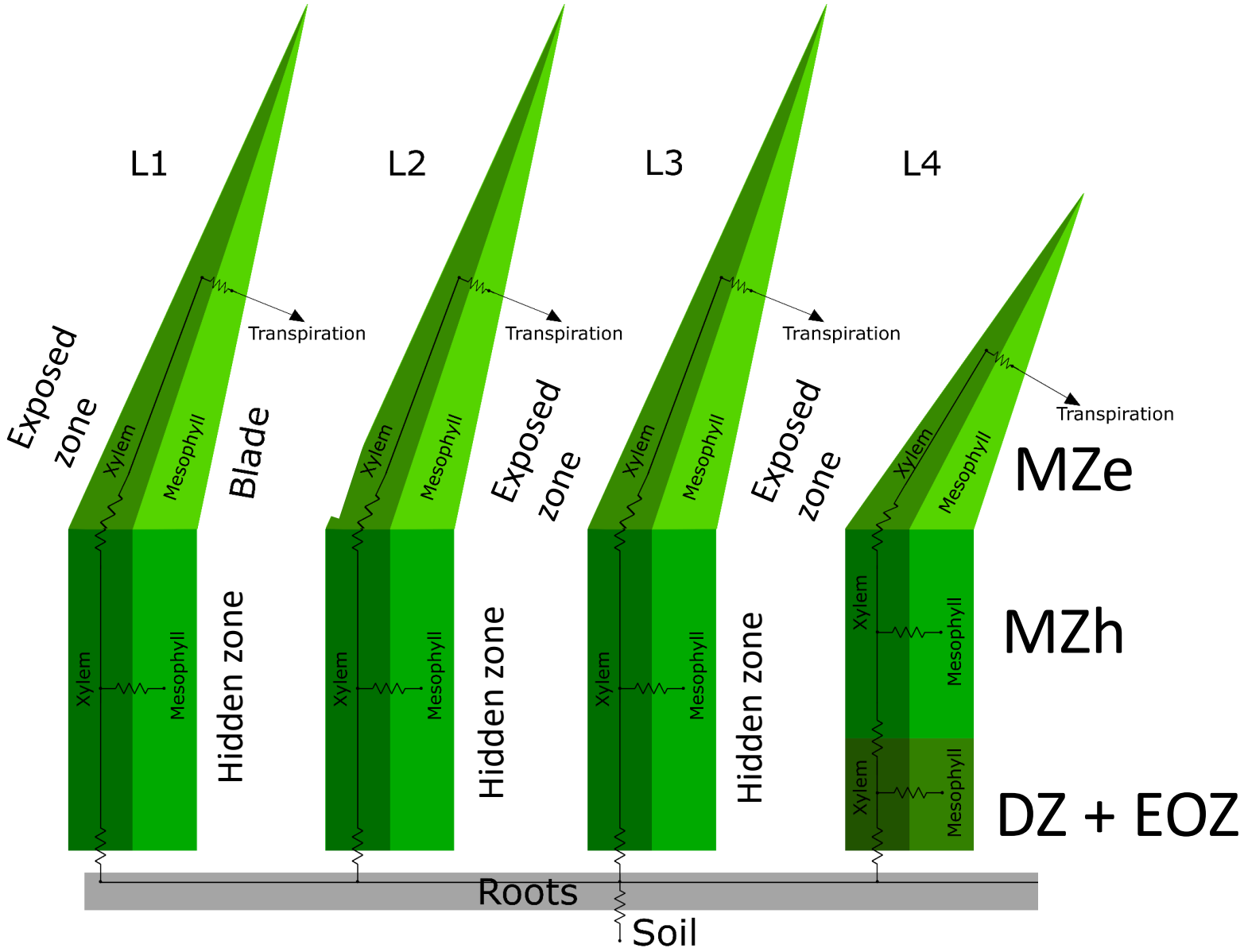
$$LER = k_1 DZ + k_2 EOZ$$







The hydraulic model: *Festuca arundinacea*



Hydraulics x Ontogeny

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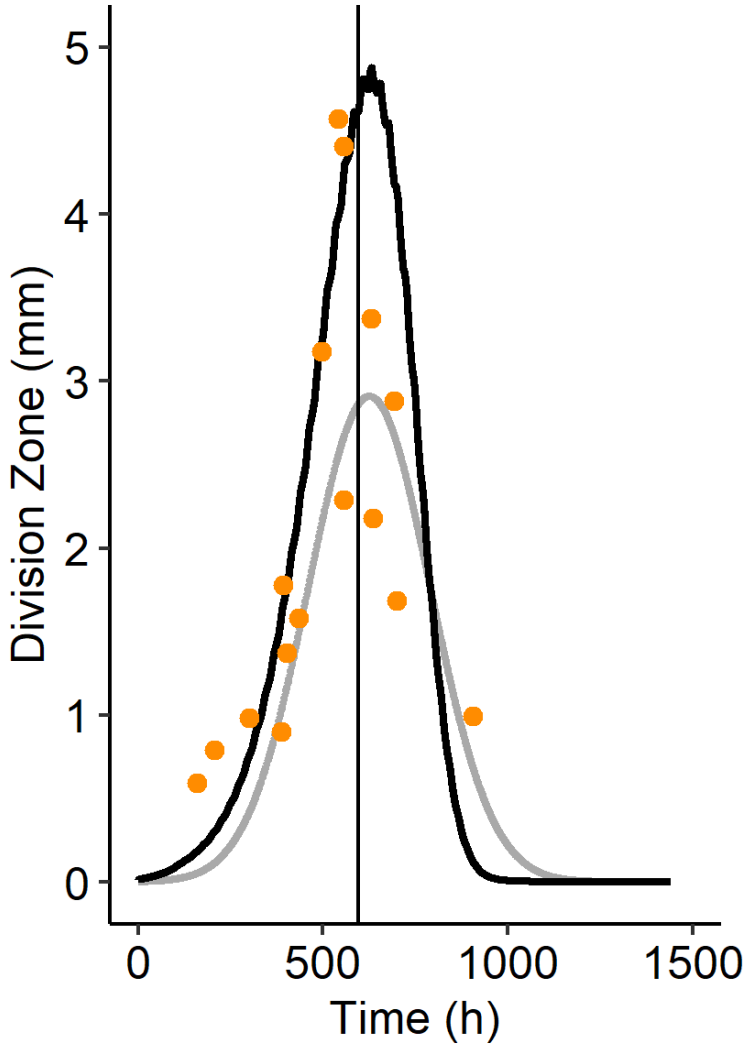
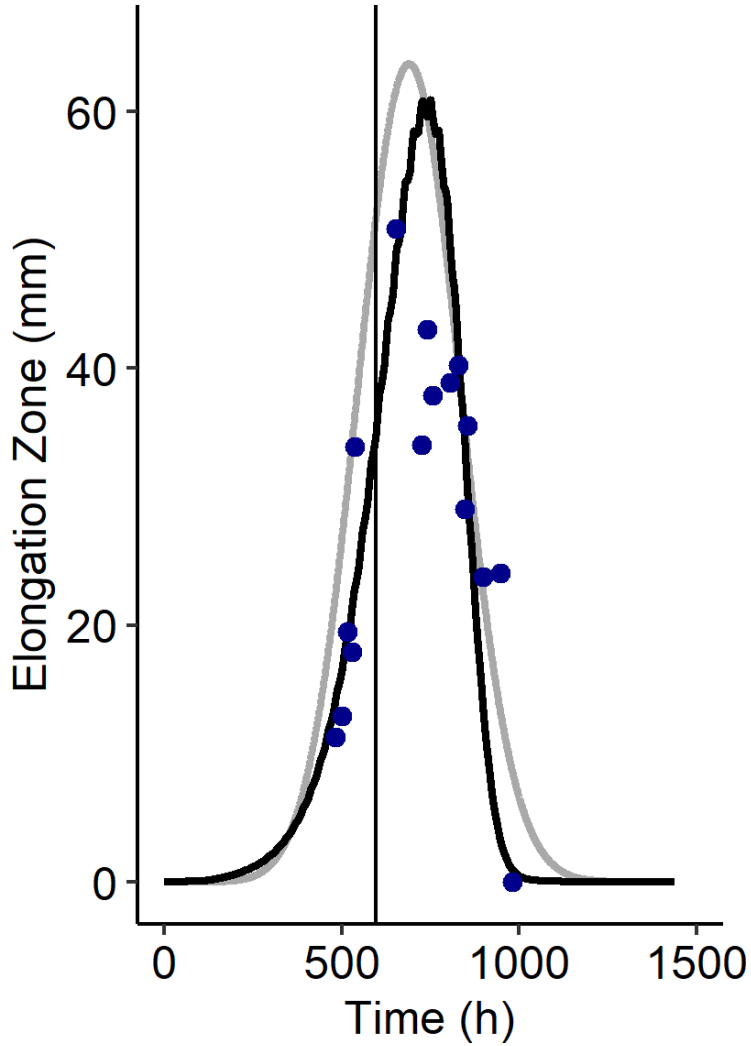
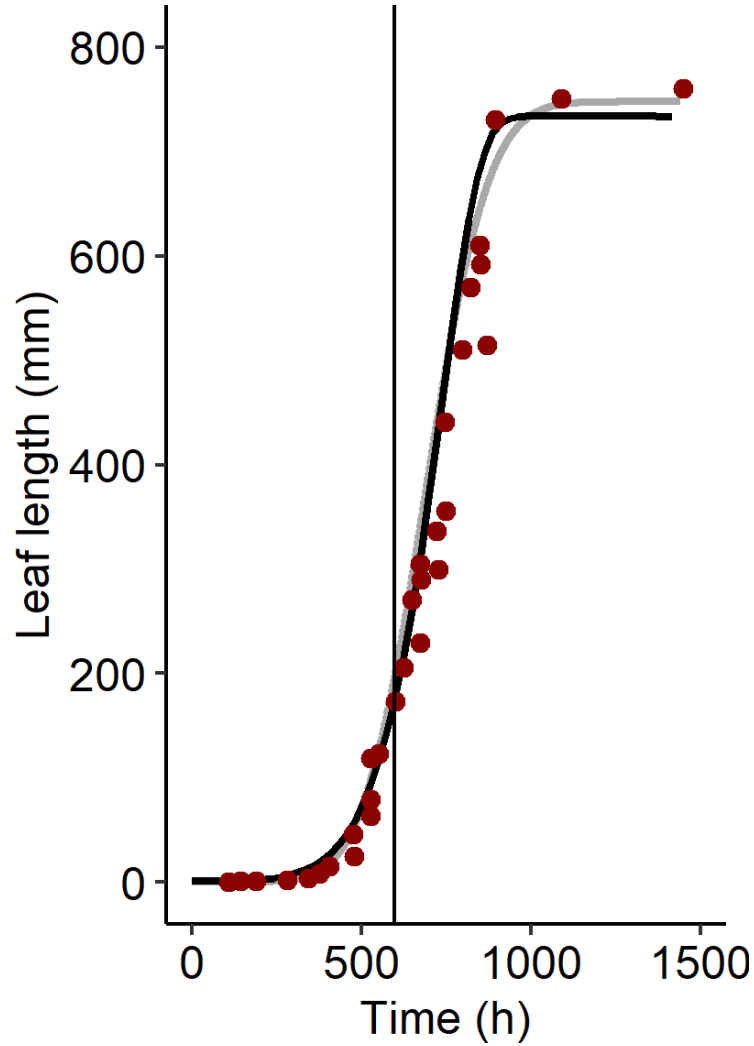
Growth

Model ontogenic “meta-mechanism”

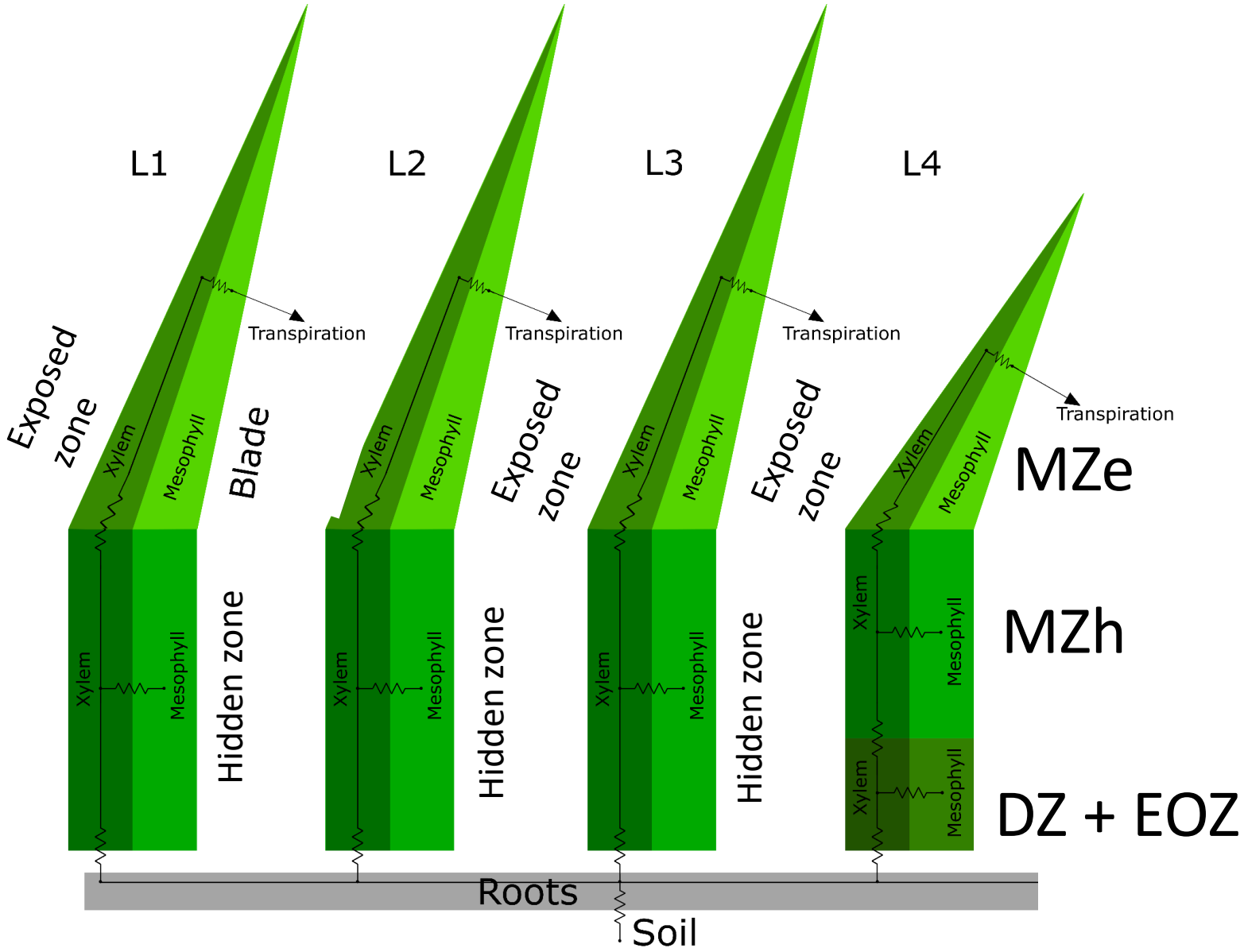
- Cells can only divide X times ?
- Cells grow until maximum cell length?
- At leaf emergence production of proliferative cells gradually stops


Division Zone (mm)
0
1
2
3
4
5
0
500
1000
1500
Time (h)


Elongation Zone (mm)
0
20
40
60
0
500
1000
1500
Time (h)


Leaf length (mm)
0
200
400
600
800
0
500
1000
1500
Time (h)

The hydraulic model: *Festuca arundinacea*



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Hydraulics x Ontogeny

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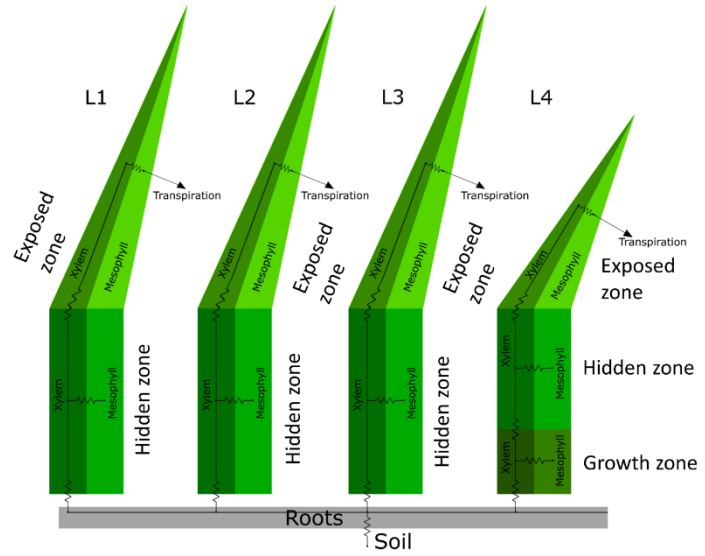
Growth

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!

Tom De Swaef
Mathias Cougnon
Romain Barillot
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ILVO
Flanders research institute for agriculture, fisheries and food

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tom.deswaef@ilvo.vlaanderen.be