Dalle cellule agli ecosistemi: l'utilità dei modelli teorici nelle scienze della vita

Fabrizio Cartenì
fabrizio.carteni@unina.it

Laboratory of Applied Ecology and System Dynamics
Department of Agricultural Sciences
University of Naples Federico II

Mi presento:

2018 – ASN II fascia

2009
Laurea in Scienze e Tecnologie Agrarie

2014
PhD (XXV ciclo)

2014 – 2018
Assegnista di ricerca DiA

2019 – 2023
RTDA

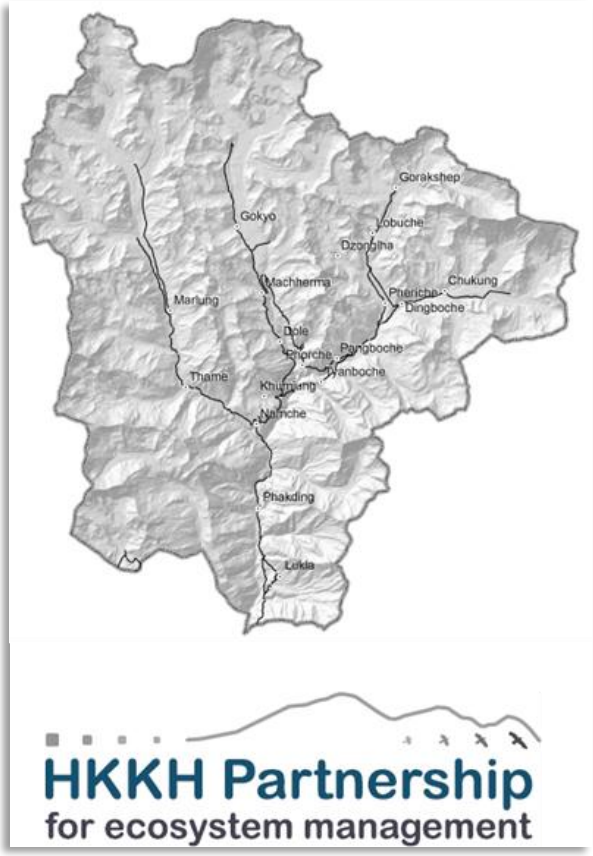
2024 – oggi
RTDB

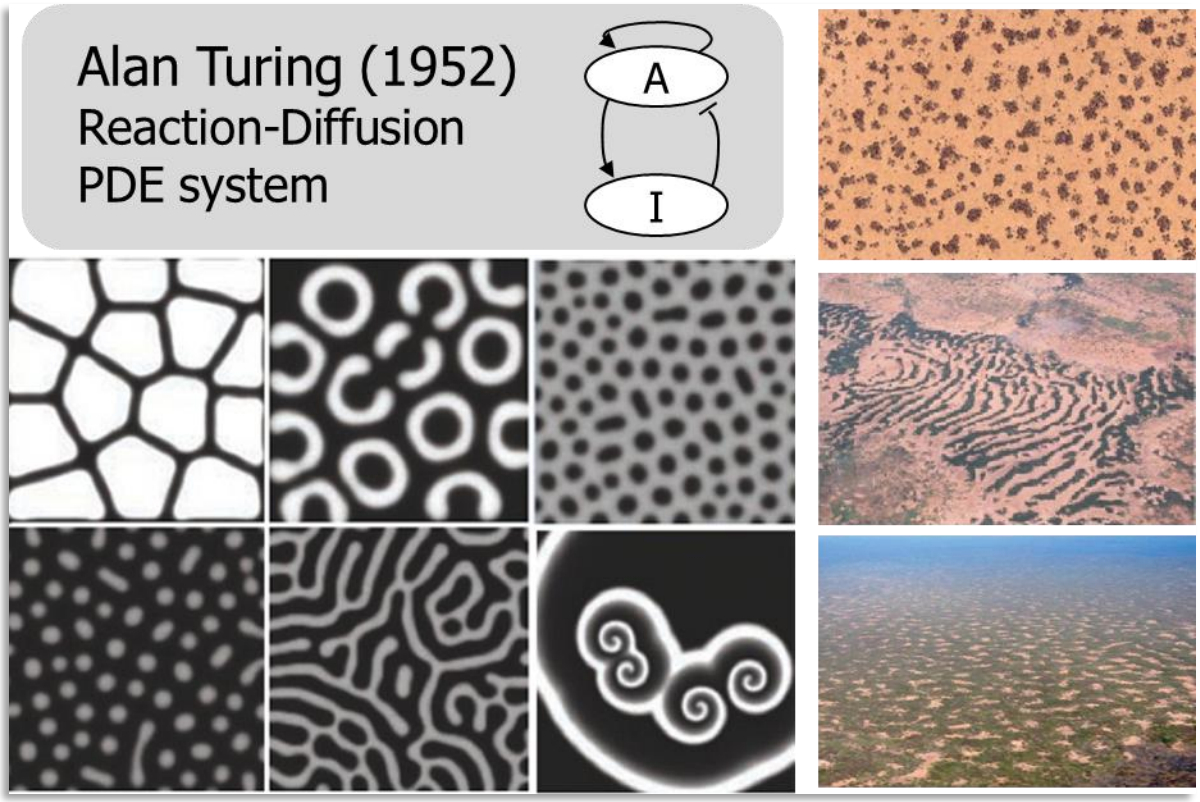
SSD: Botanica Ambientale ed Applicata (BIOS-01/C)

Docente di Botanica Generale e Sistematica al CdL in VE

Attività di ricerca:

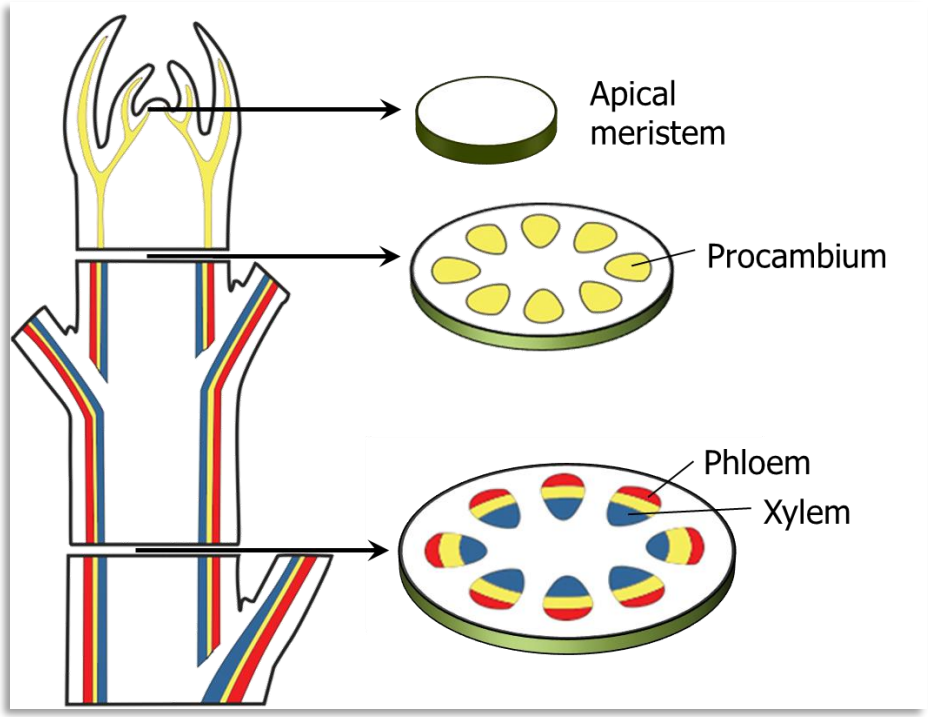
- Utilizzo di approcci modellistici per studiare fenomeni naturali in contesti molto diversi

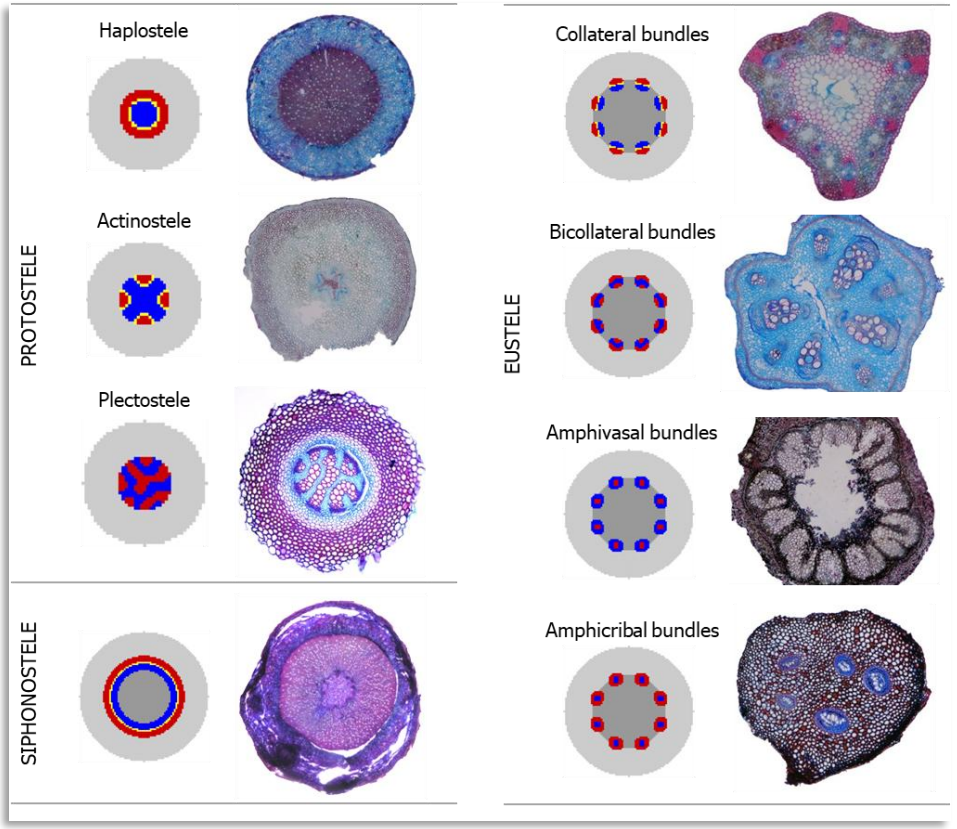




Attività di ricerca:

- Differenziazione dei fasci vascolari nelle piante

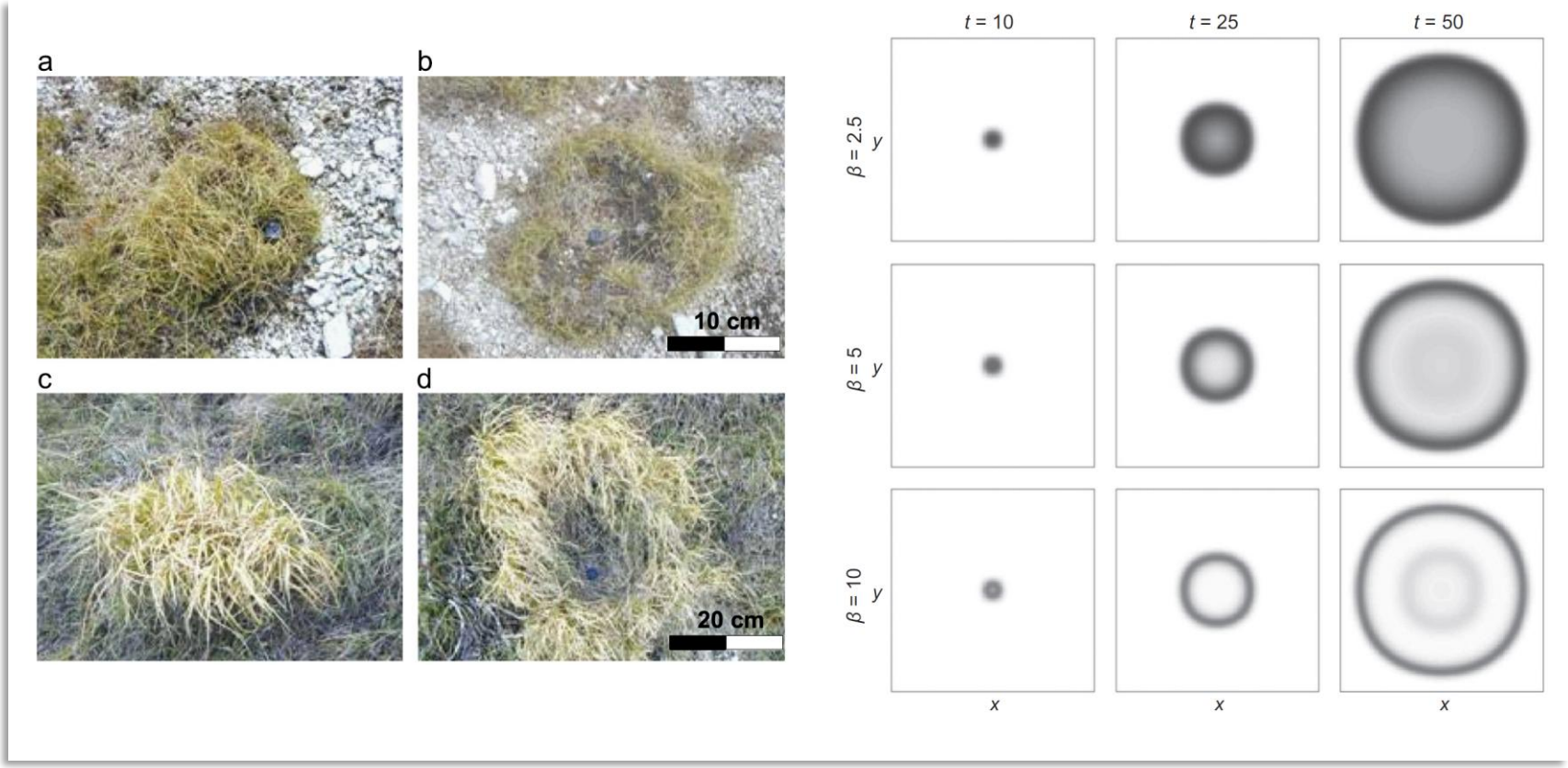




Cartenì F, Giannino F, Schweingruber FH, Mazzoleni S. Modelling the development and arrangement of the primary vascular structure in plants. Ann Bot. 2014;114(4):619-27.

Attività di ricerca:

- Pattern di vegetazione



Cartenì F, Marasco A, Bonanomi G, Mazzoleni S, Rietkerk M, Giannino F. Negative plant soil feedback explaining ring formation in clonal plants. J Theor Biol. 2012;313:153-61.

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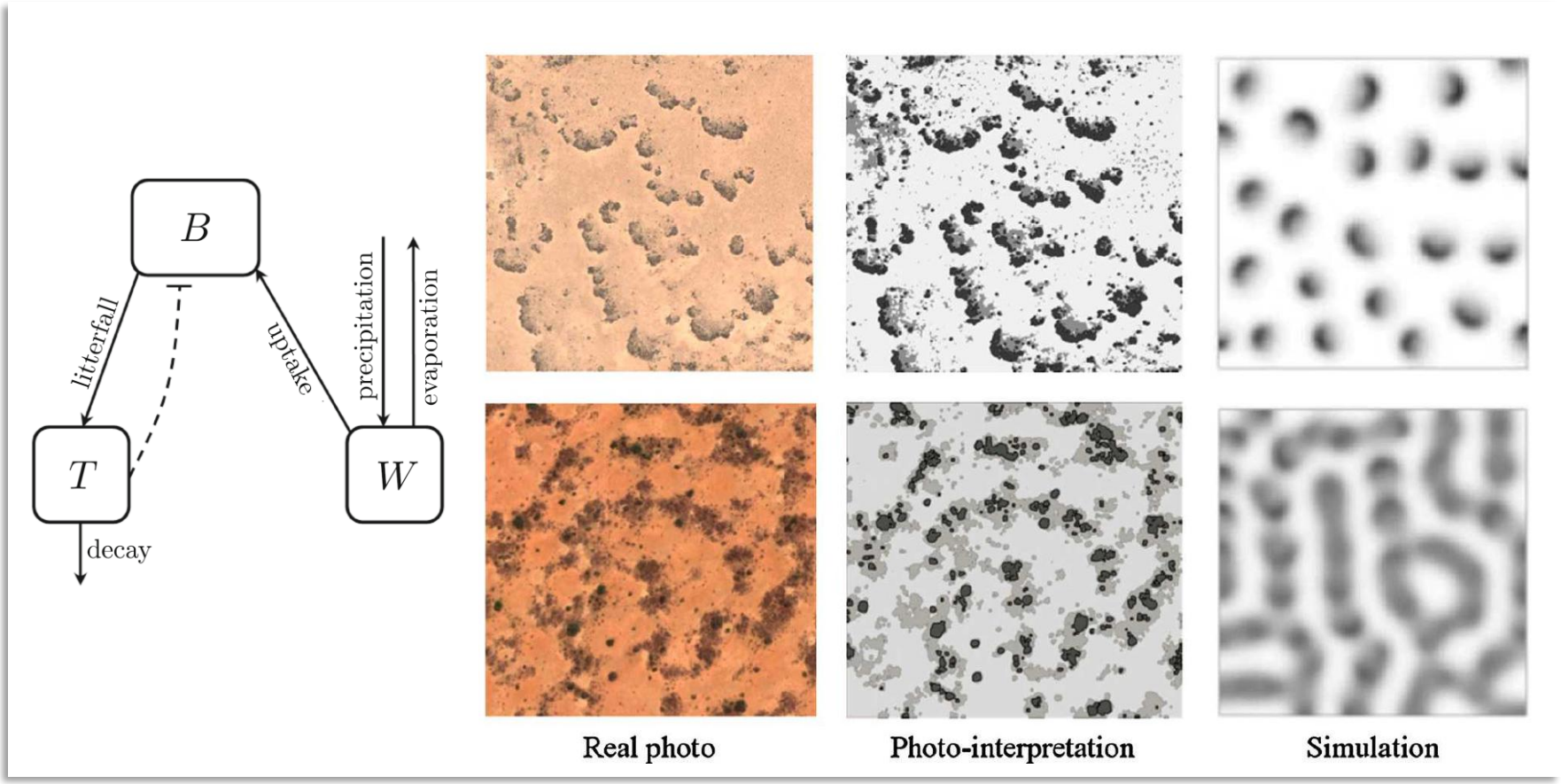
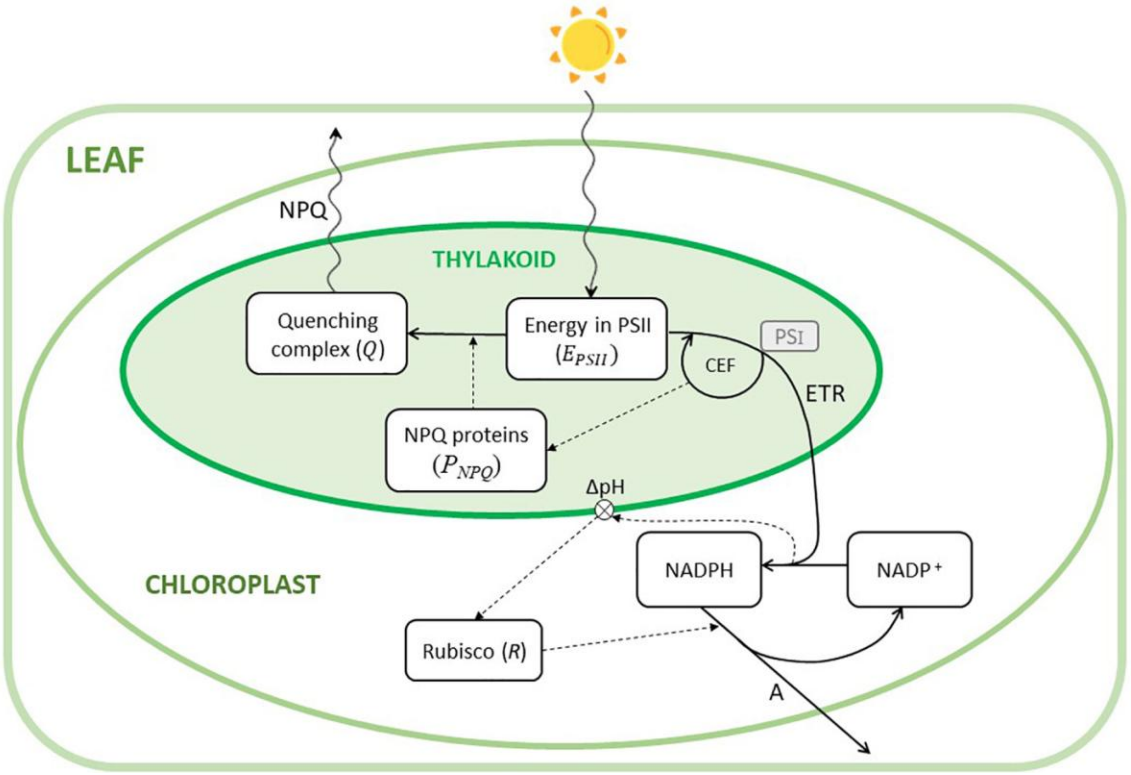
- Pattern di vegetazione

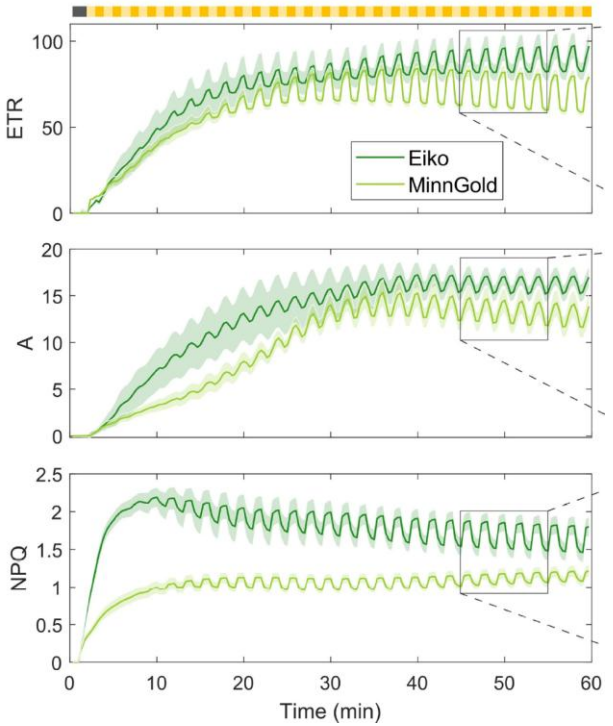


Marasco A, Iuorio A, Carteni F, Bonanomi G, Tartakovsky D, Mazzoleni S, et al. Vegetation Pattern Formation Due to Interactions Between Water Availability and Toxicity in Plant-Soil Feedback. Bull Math Biol. 2014;76(11):2866-83.

Attività di ricerca:

- Fotosintesi dinamica

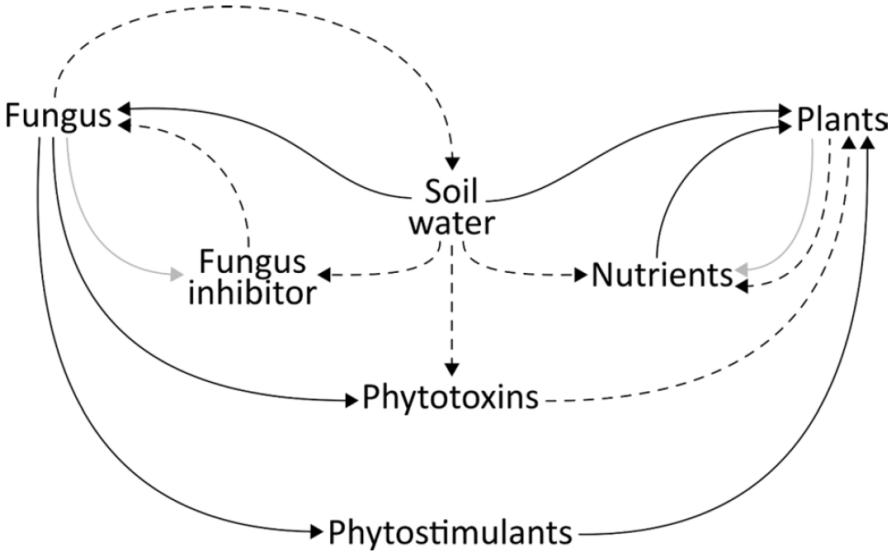


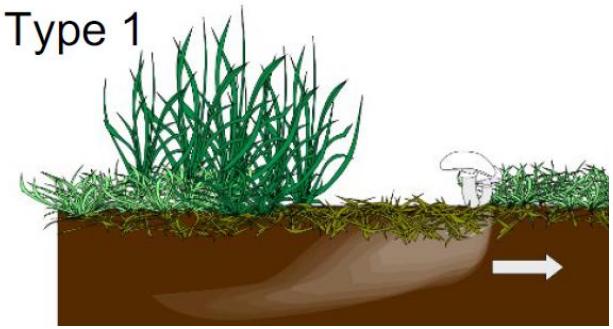


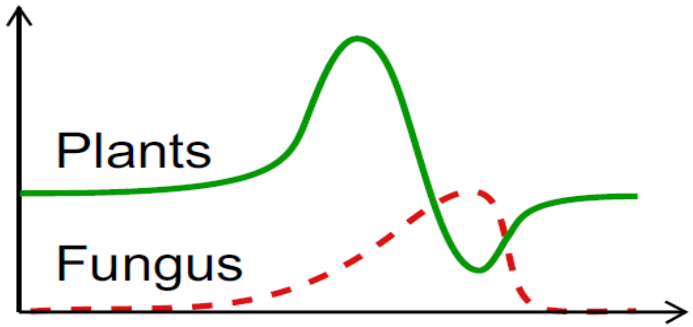
Salvatori N, Carteni F, Giannino F, Alberti G, Mazzoleni S, Peressotti A. A System Dynamics Approach to Model Photosynthesis at Leaf Level Under Fluctuating Light. Front Plant Sci. 2022;12:16.

Attività di ricerca:

- Fairy Rings – interazioni pianta-fungo



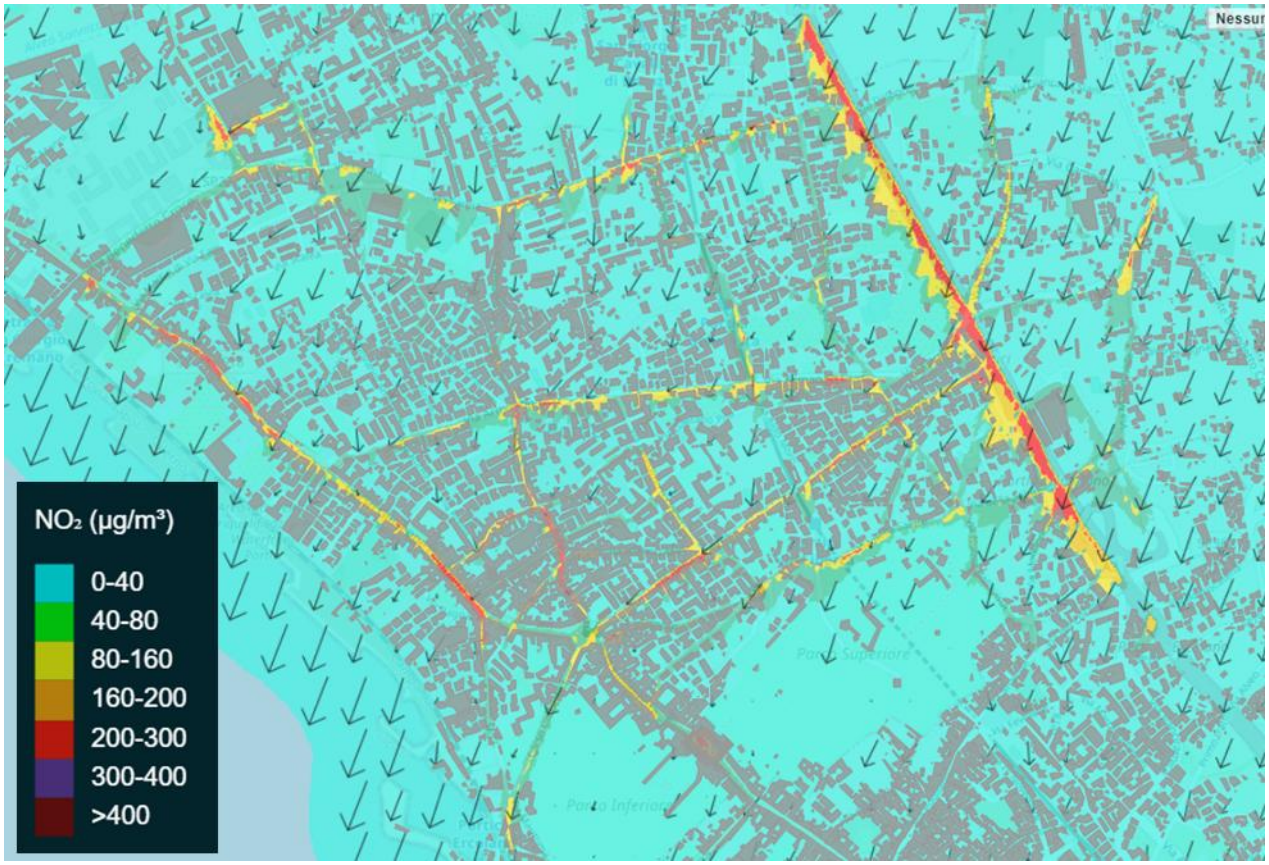




Salvatori N, Moreno M, Zotti M, Iuorio A, Carteni F, Bonanomi G, et al. Process based modelling of plants-fungus interactions explains fairy ring types and dynamics. Sci Rep. 2023;13(1):13.

Attività di ricerca:

- Utilizzo di approcci modellistici per studiare fenomeni naturali in contesti molto diversi



AIR HERITAGE

UIA URBAN INNOVATIVE ACTIONS

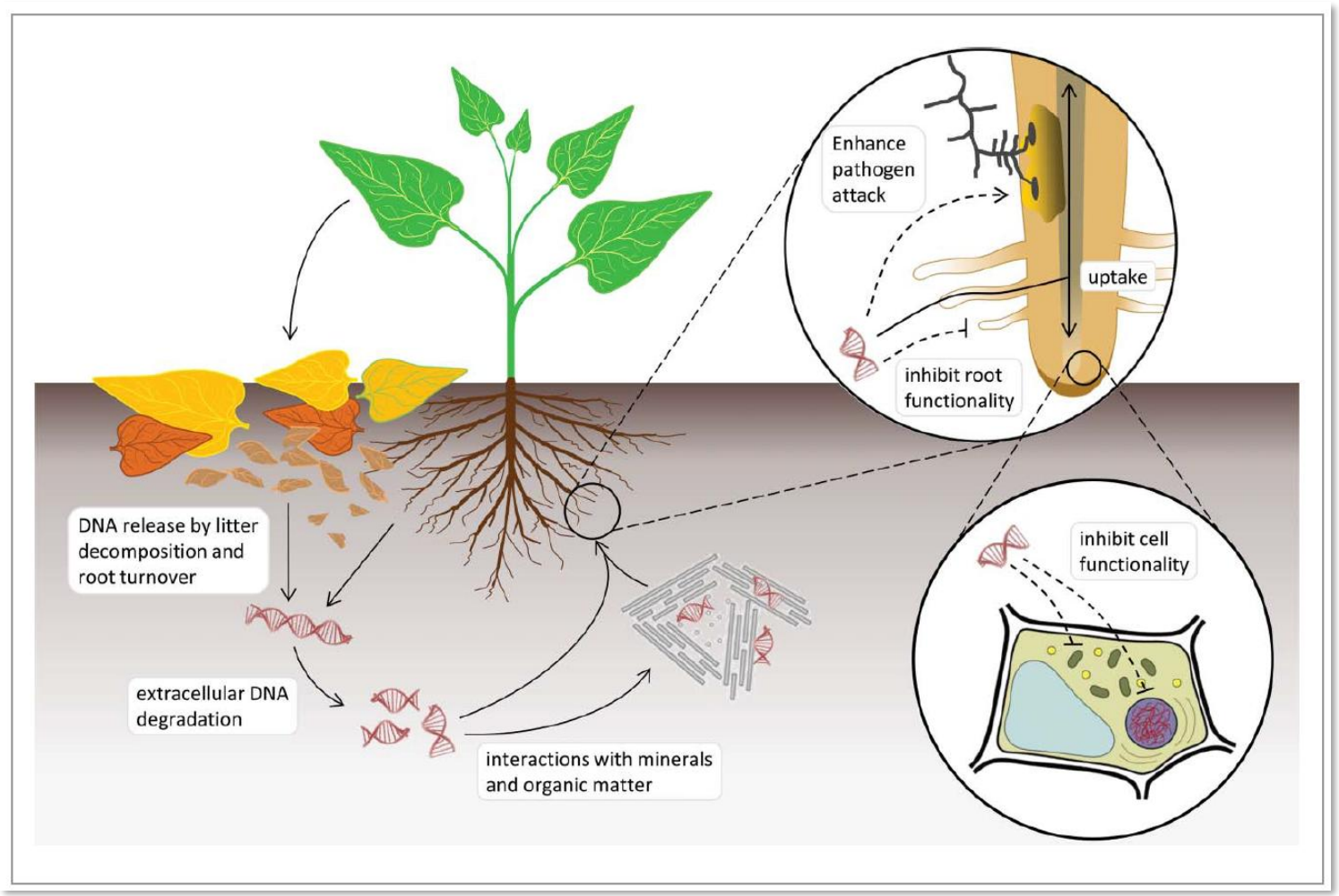
PORTICI

EUROPEAN UNION
European Regional Development Fund

https://uiaairheritage-portici.it

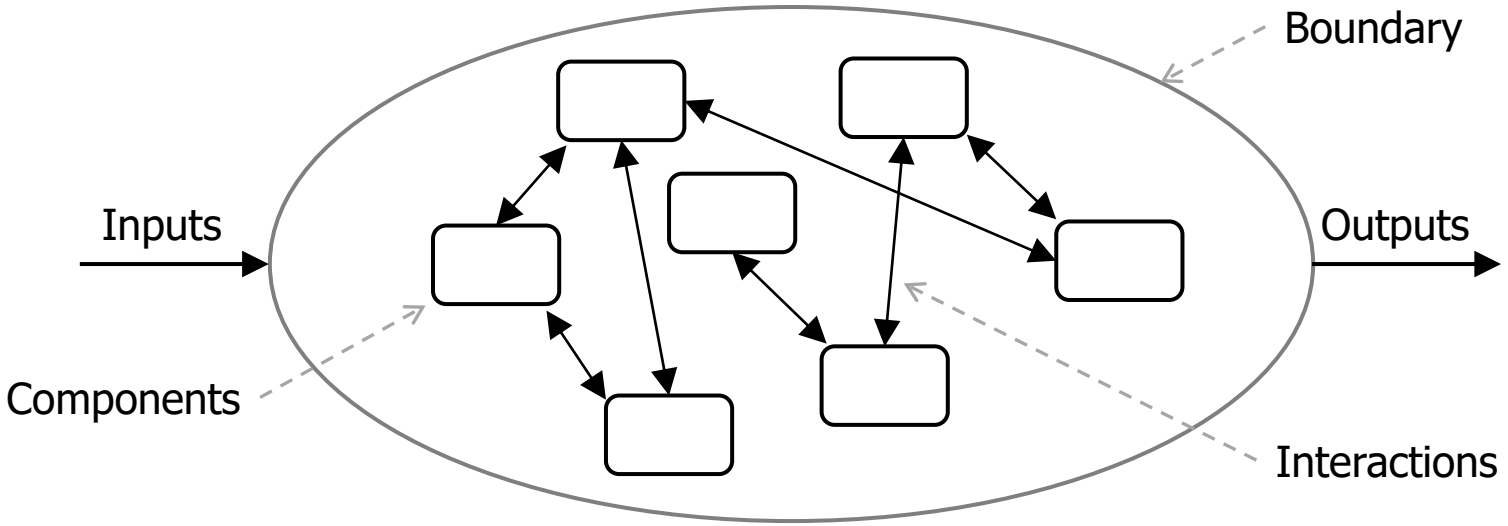
Attività di ricerca:

- Inibizione da self-DNA extracellulare



Cartenì F et al. Self-DNA inhibitory effects: Underlying mechanisms and ecological implications. Plant Signaling & Behavior. 2016;11(4):e1158381-e.

System: a set of interacting or interdependent components forming a complex or intricate whole. Every system is defined by its spatial and temporal boundaries and the interactions with its environment and surroundings.



Mathematical Modelling

- Statistical approach

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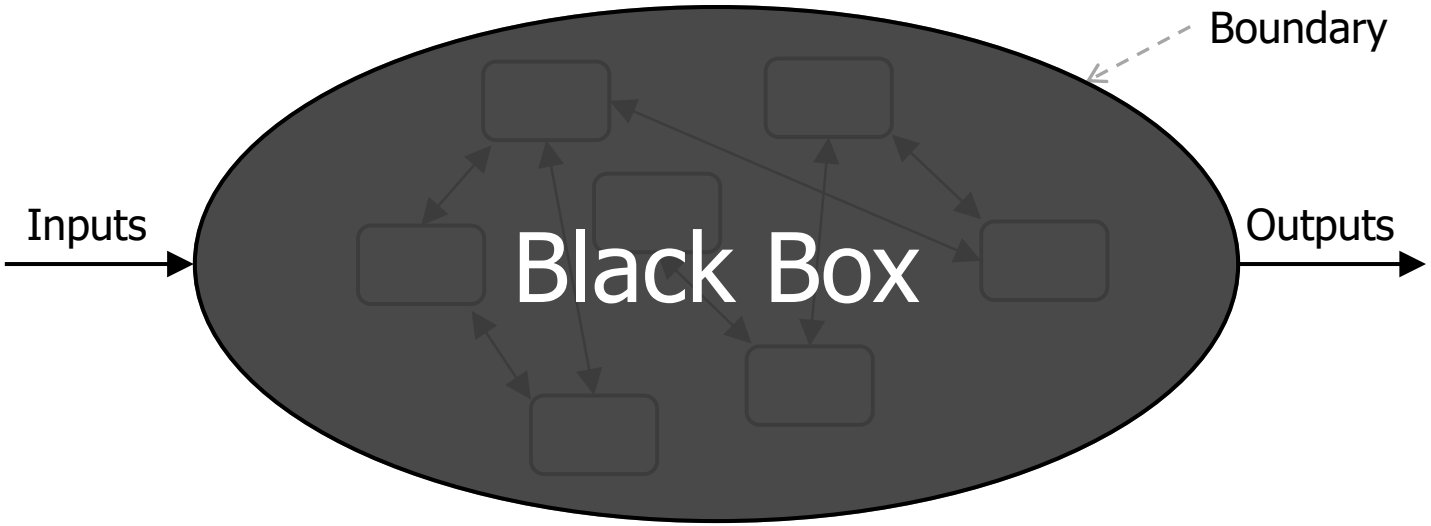

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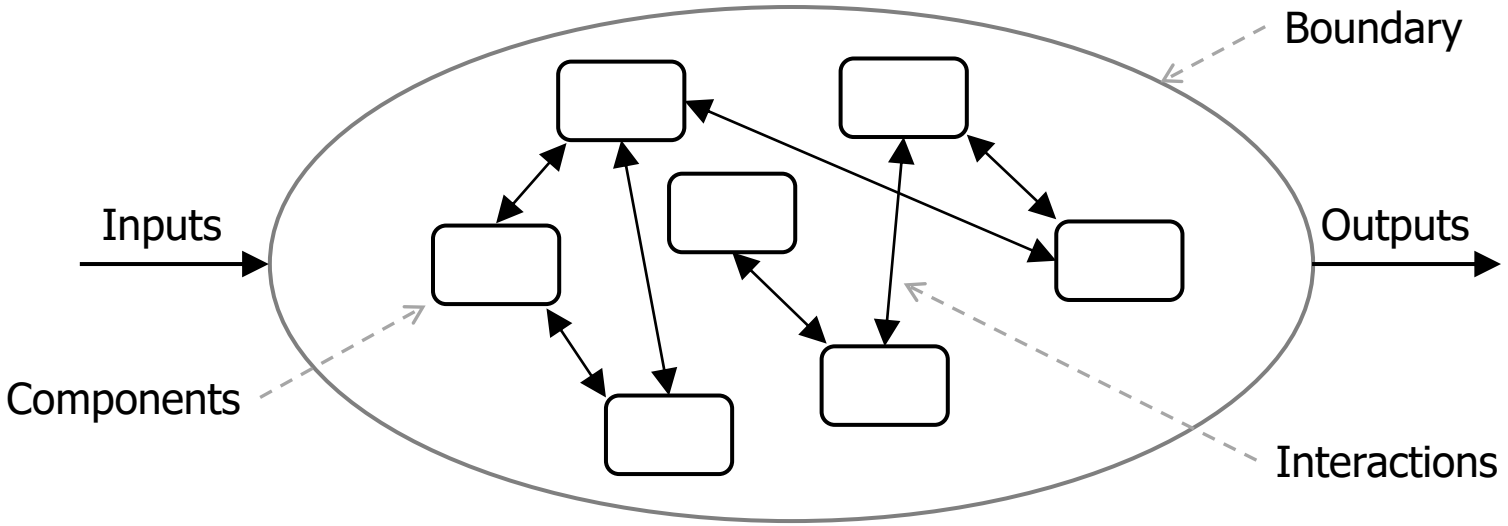
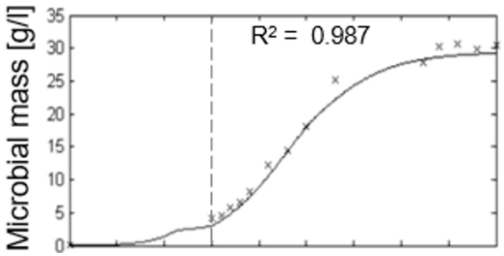


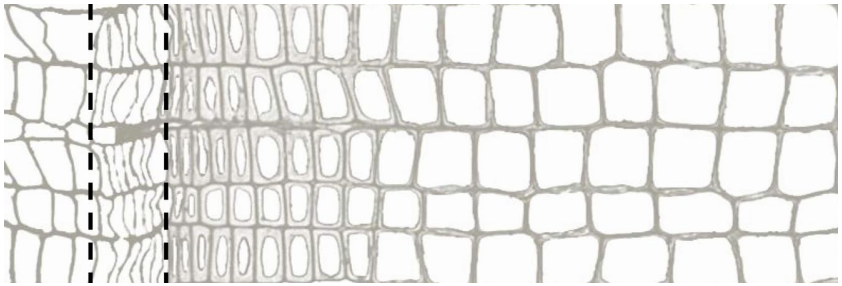
Mathematical Modelling

- Statistical approach
- Mechanistic/Process-based approach

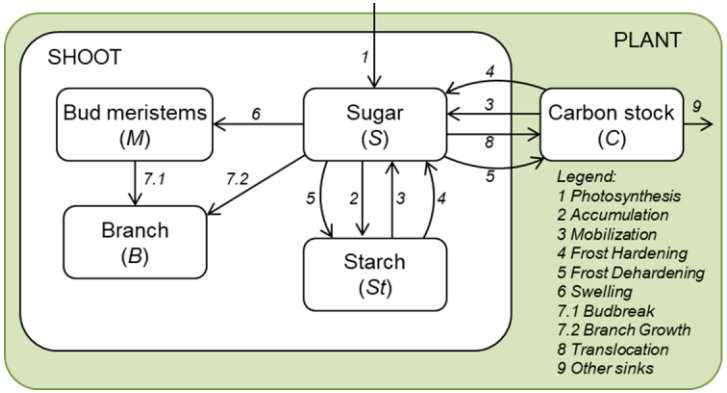
- Scala cellulare



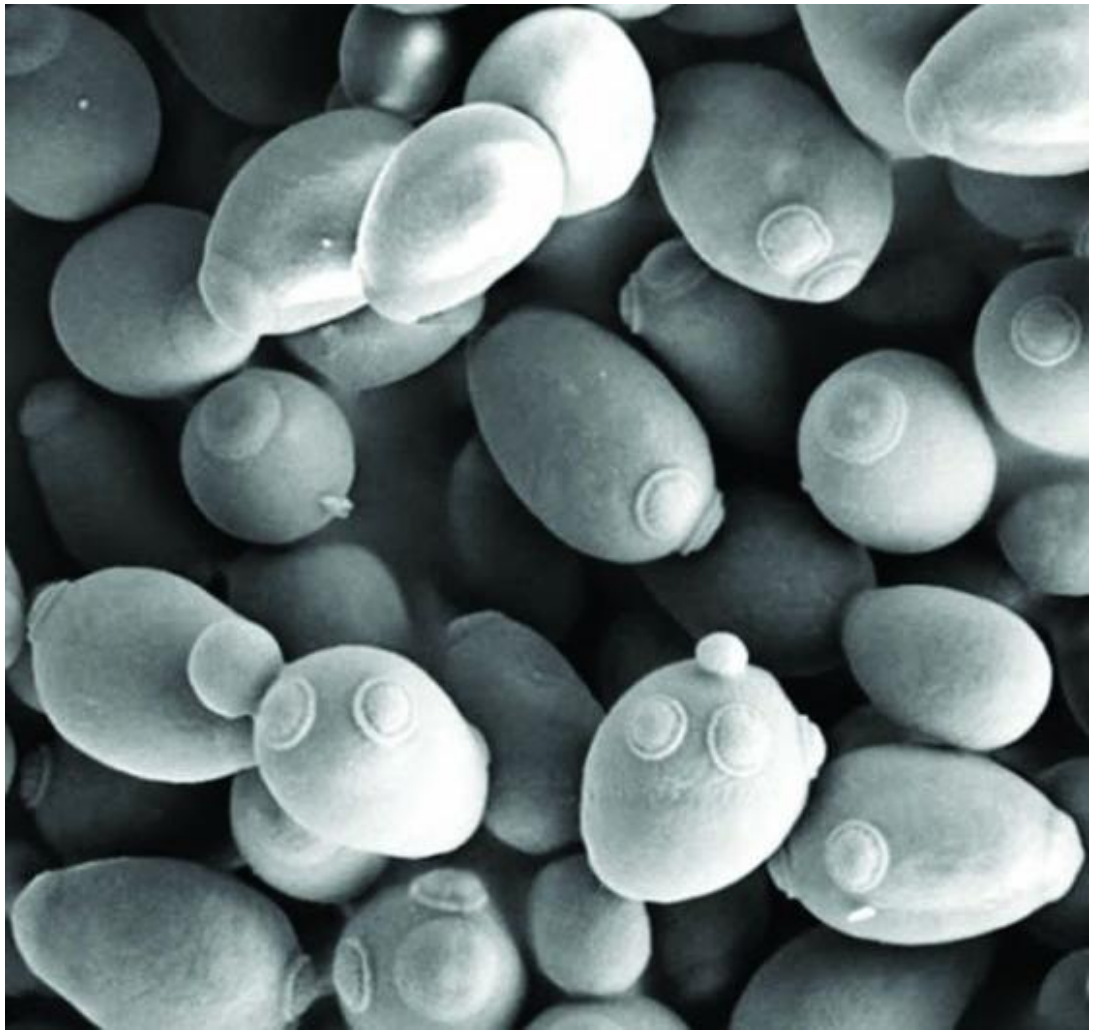
- Scala tessuto

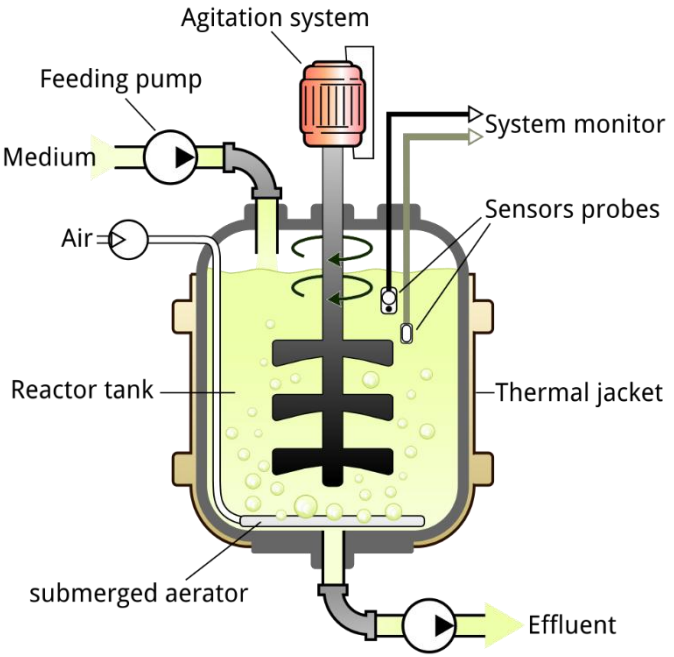


- Scala individuo



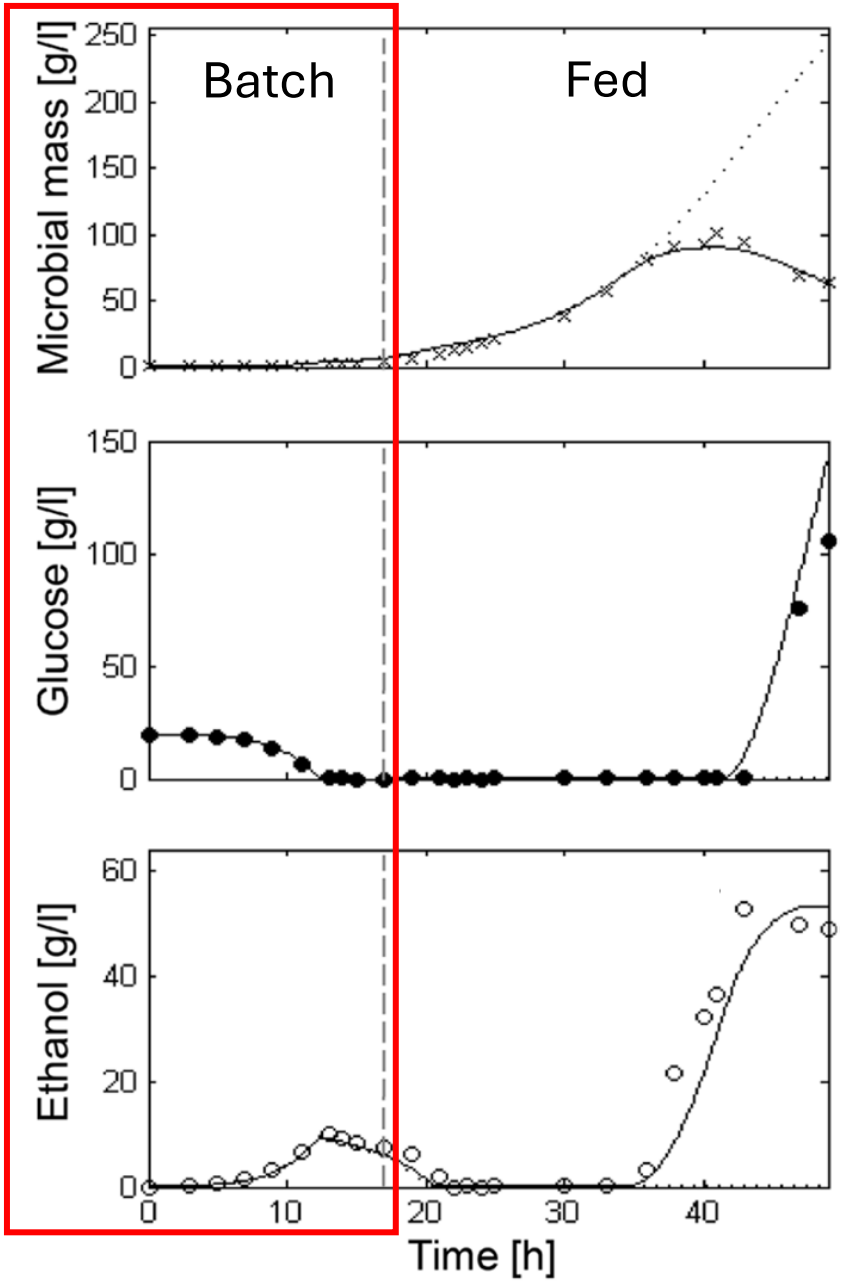
Saccharomyces cerevisiae fed-batch





Problem:

- Explain growth stop
- Explain metabolic switch to fermentation (with O_2)



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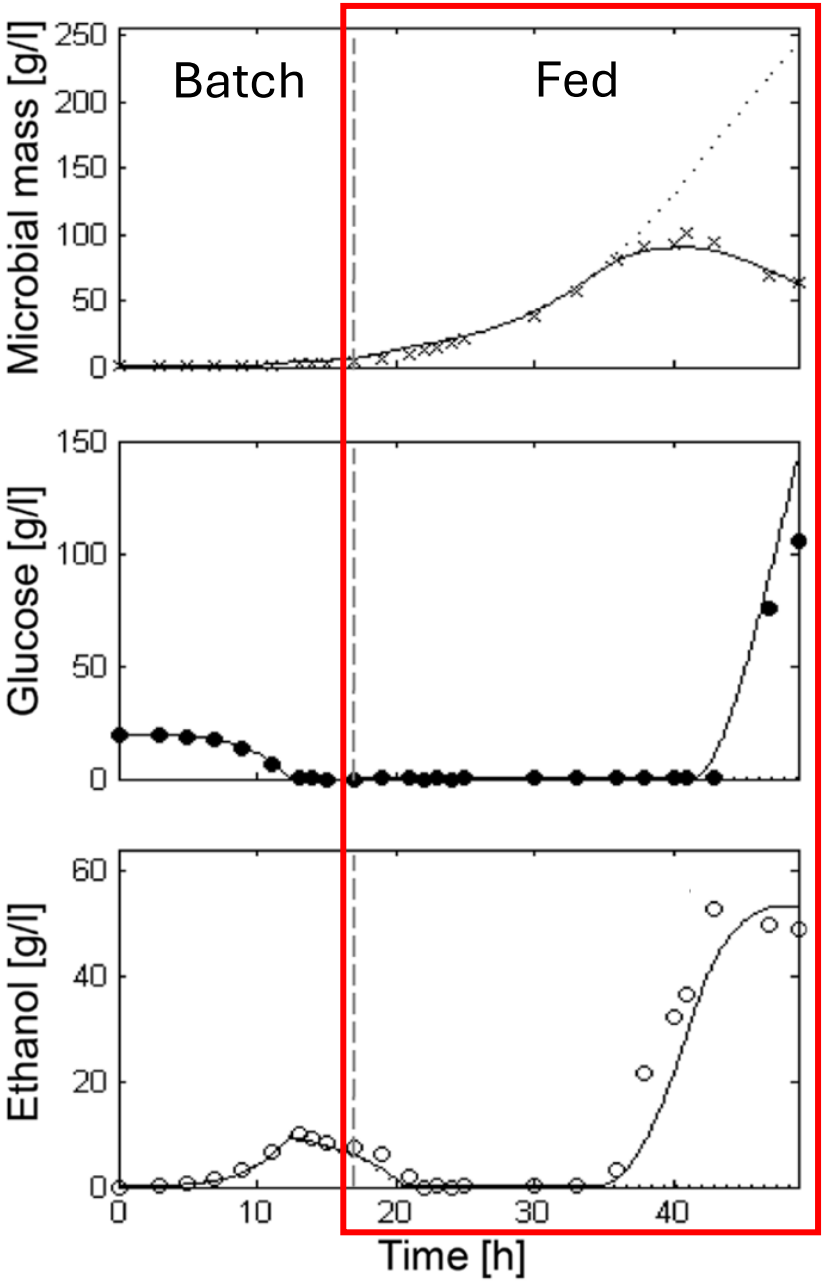
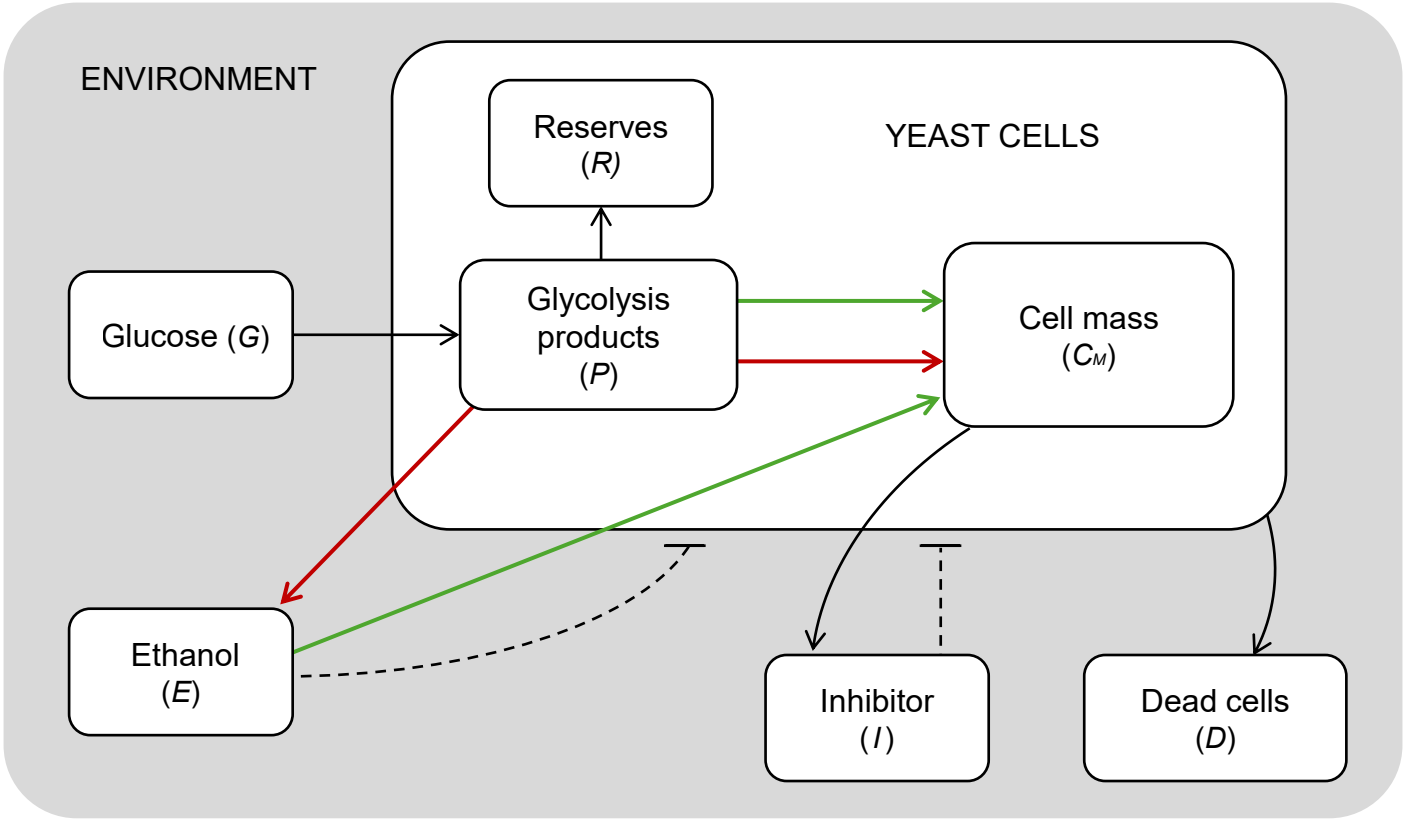
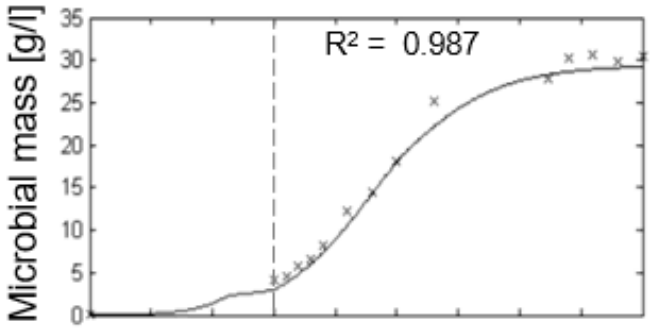


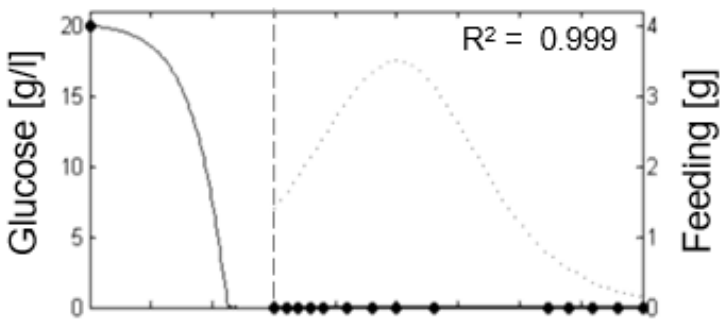

ENVIRONMENT
YEAST CELLS
Reserves
(R)
Glucose (G)
Glycolysis
products
(P)
Cell mass
(CM)
Ethanol
(E)
Inhibitor
(I)
Dead cells
(D)

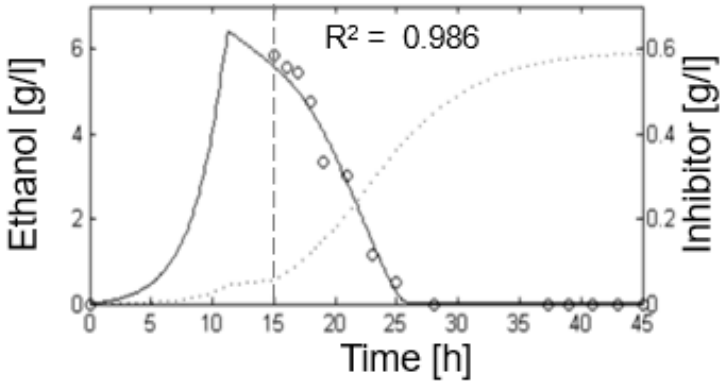
Can the model do more?

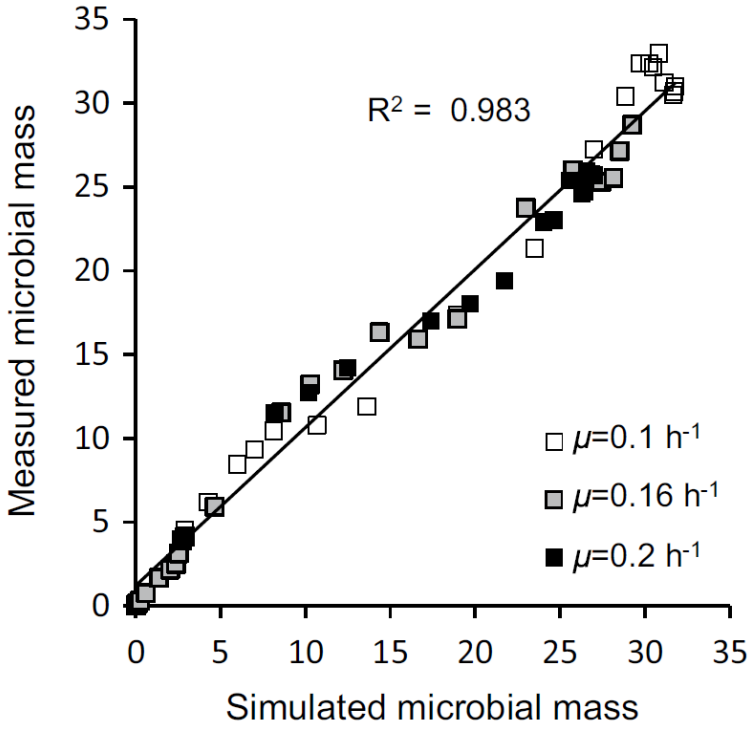
Optimise feeding

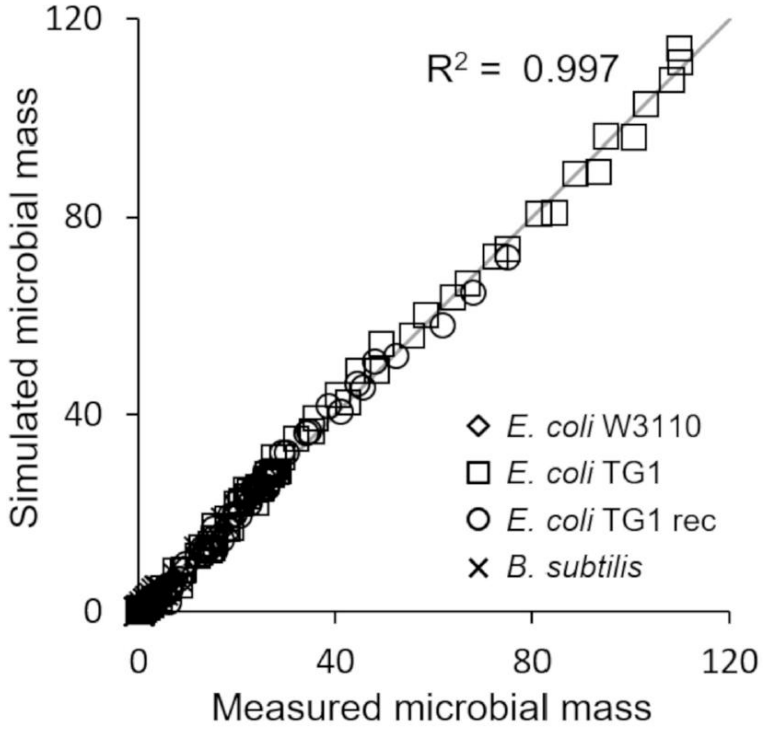
- Same biomass yield
- 50 times less nutrients
- No ethanol production











Mazzoleni et al. Microb Cell Fact (2015) 14:109
DOI 10.1186/s12934-015-0295-4

MICROBIAL CELL FACTORIES

RESEARCH Open Access

A novel process-based model of microbial growth: self-inhibition in *Saccharomyces cerevisiae* aerobic fed-batch cultures

Stefano Mazzoleni[1*], Carmine Landi[2†], Fabrizio Carteni[1†], Elisabetta de Alteriis[3], Francesco Giannino[1], Lucia Paciello[2] and Palma Parascandola[2]

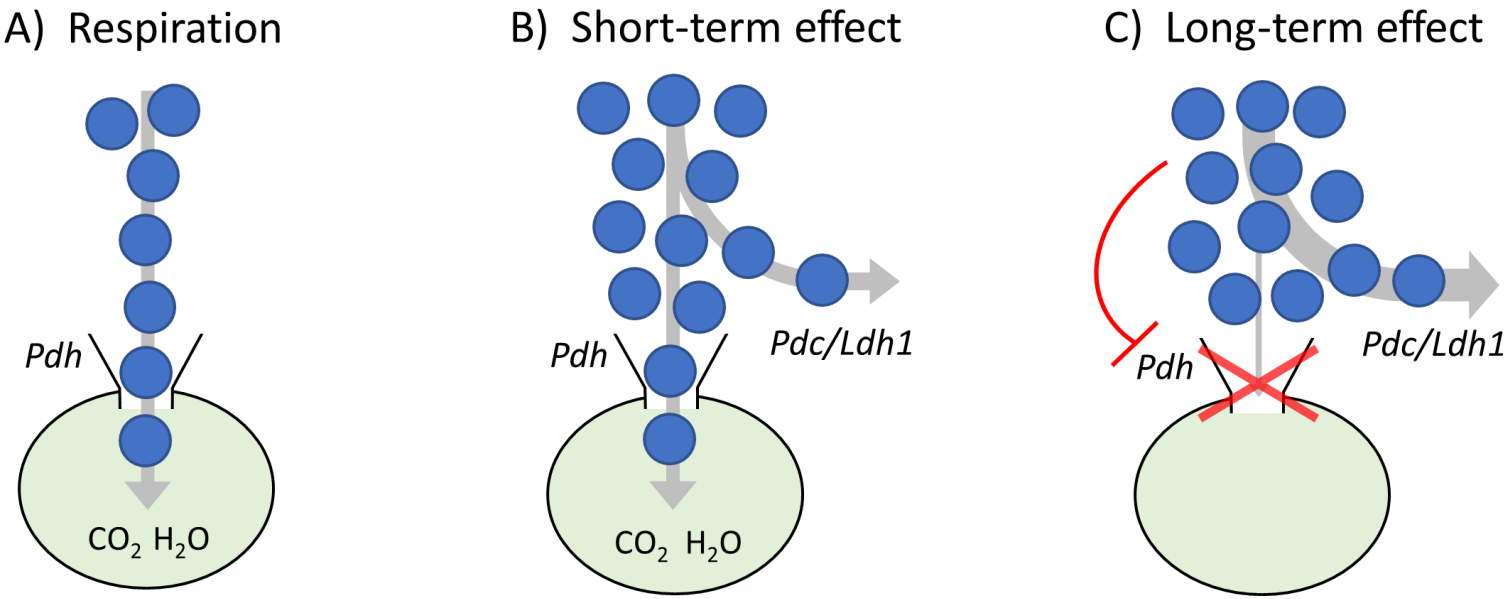
frontiers in Microbiology

ORIGINAL RESEARCH
published: 30 September 2020
doi: 10.3389/fmicb.2020.521368

A General Process-Based Model for Describing the Metabolic Shift in Microbial Cell Cultures

Fabrizio Carteni[1], Alessio Occhicone[1,2], Francesco Giannino[1], Christian E. Vincenot[3], Elisabetta de Alteriis[4], Emanuela Palomba[1,5] and Stefano Mazzoleni[1]*

The Crabtree / Warburg effect



CELL CYCLE, 2018
VOL. 17, NO. 6, 688–701
https://doi.org/10.1080/15384101.2018.1442622

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REVIEW

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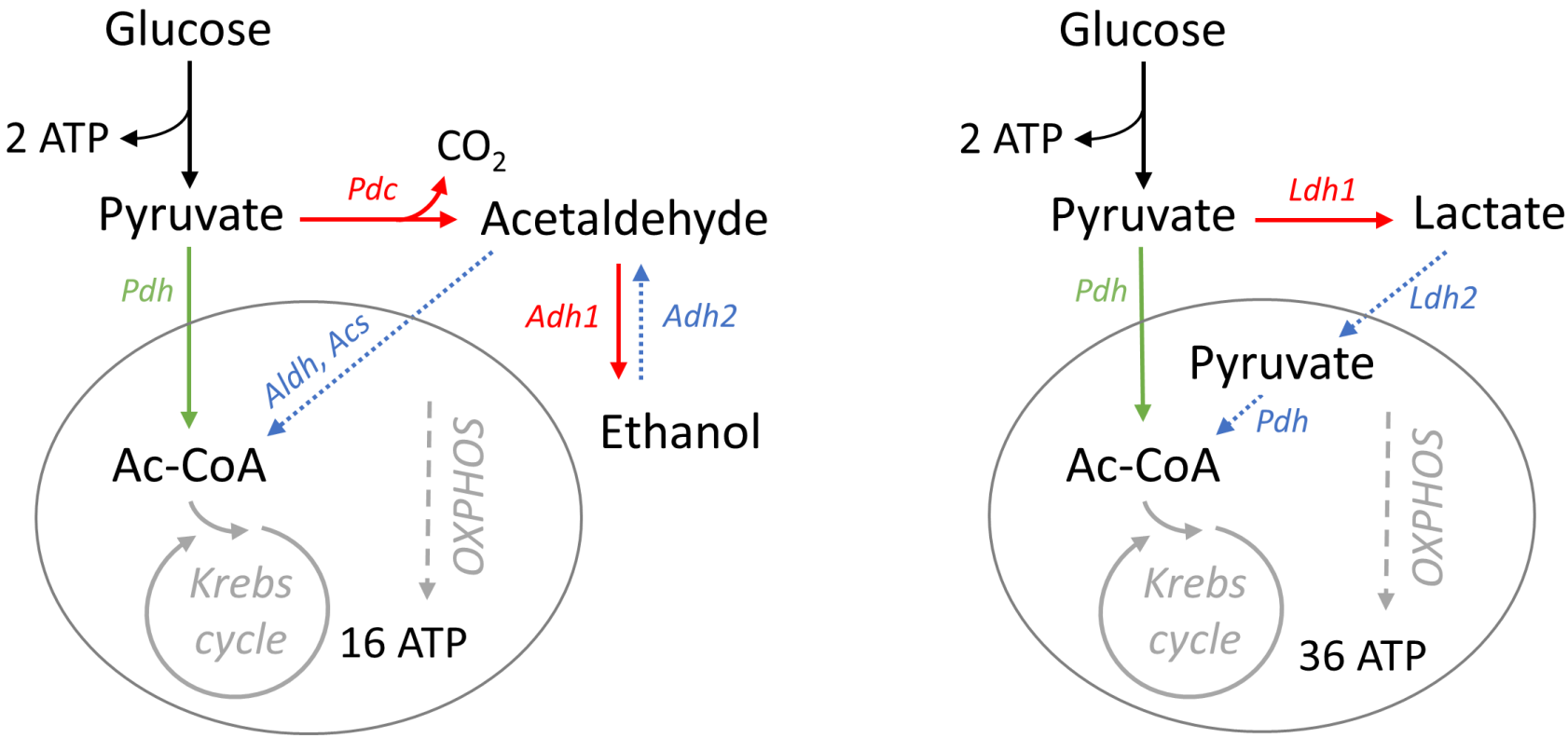
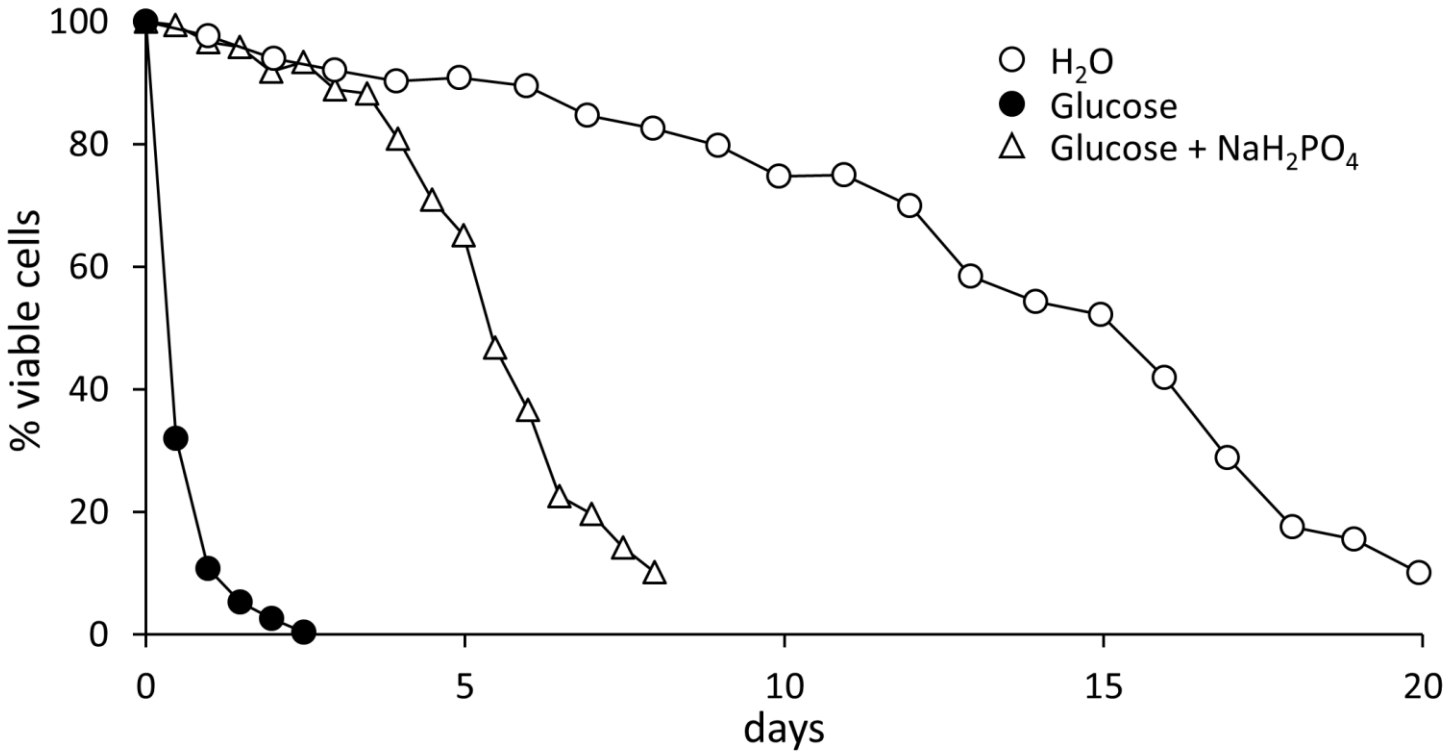
Revisiting the Crabtree/Warburg effect in a dynamic perspective: a fitness advantage against sugar-induced cell death

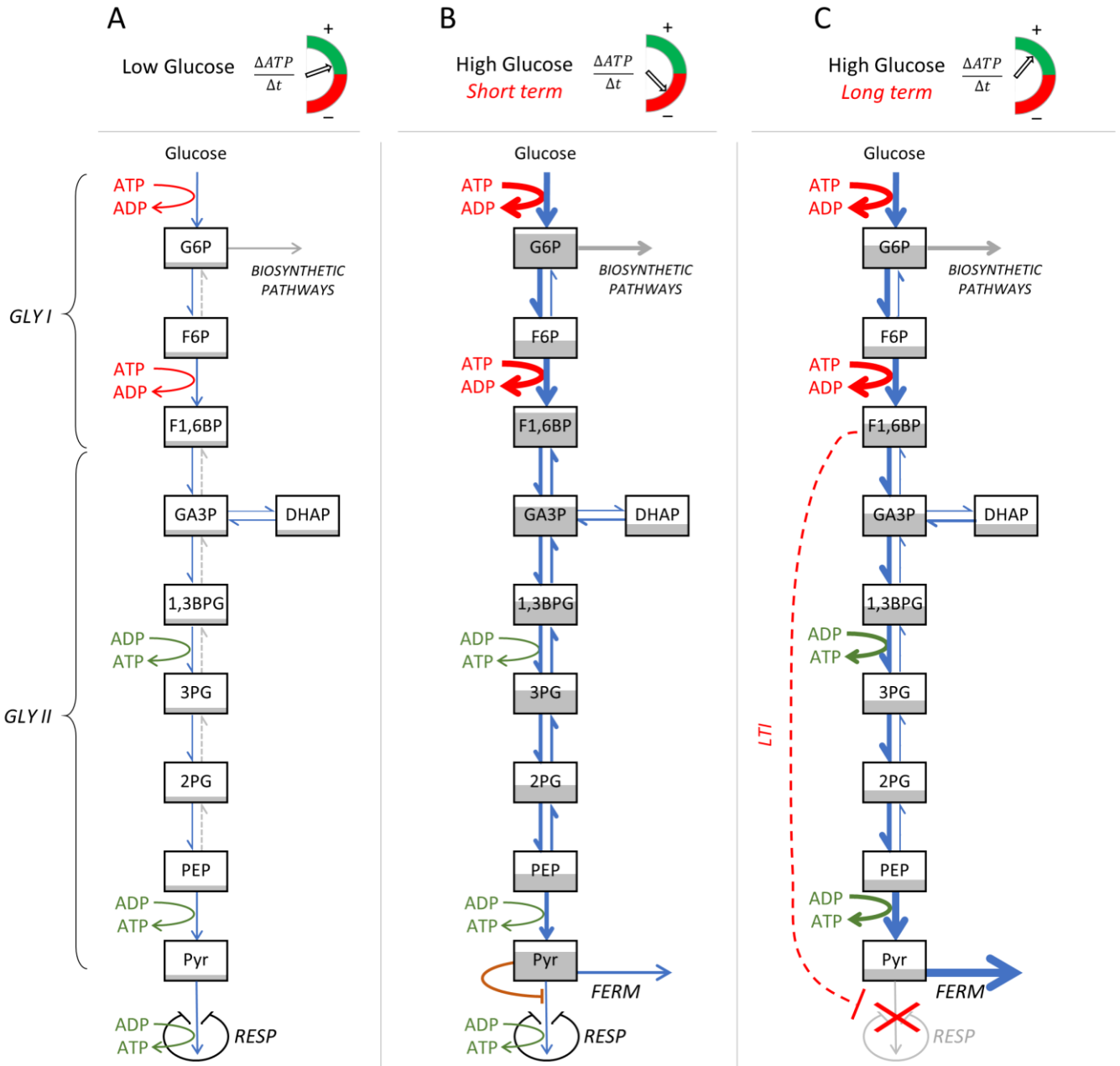
Elisabetta de Alteriis[a]*, Fabrizio Cartenì[b]*, Palma Parascandola[c], Jacinta Serpa[d,e] and Stefano Mazzoleni[b]

The Crabtree / Warburg effect



Sugar-induced Cell Death (SICD)




A
Low Glucose
ΔATP/Δt
+
−
Glucose
ATP
ADP
G6P
BIOSYNTHETIC PATHWAYS
F6P
ATP
ADP
F1,6BP
GA3P
DHAP
1,3BPG
ADP
ATP
3PG
2PG
PEP
ADP
ATP
Pyr
ADP
ATP
RESP
GLY I
GLY II
B
High Glucose
Short term
ΔATP/Δt
+
−
Glucose
ATP
ADP
G6P
BIOSYNTHETIC PATHWAYS
F6P
ATP
ADP
F1,6BP
GA3P
DHAP
1,3BPG
ADP
ATP
3PG
2PG
PEP
ADP
ATP
Pyr
FERM
ADP
ATP
RESP
C
High Glucose
Long term
ΔATP/Δt
+
−
Glucose
ATP
ADP
G6P
BIOSYNTHETIC PATHWAYS
F6P
ATP
ADP
F1,6BP
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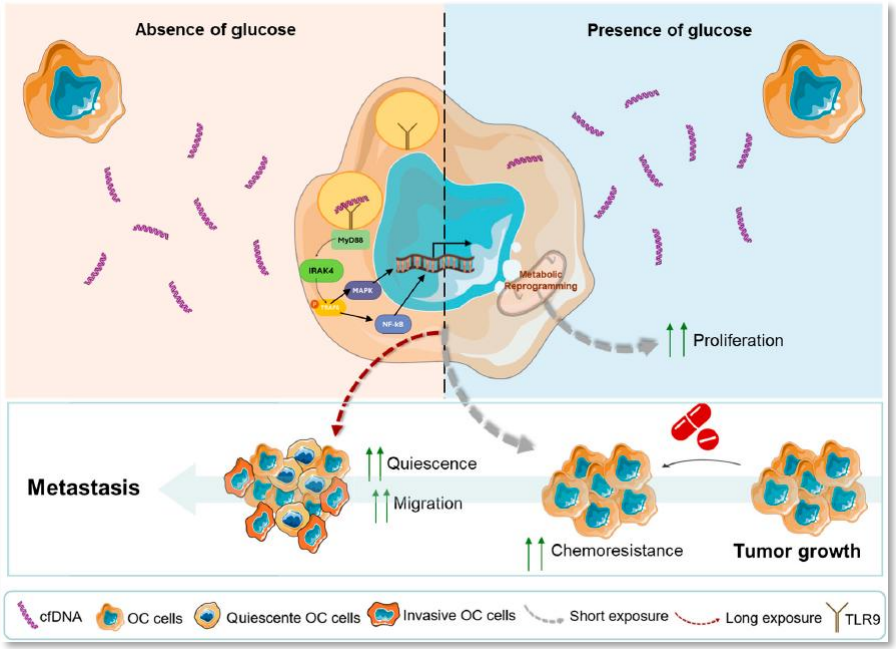
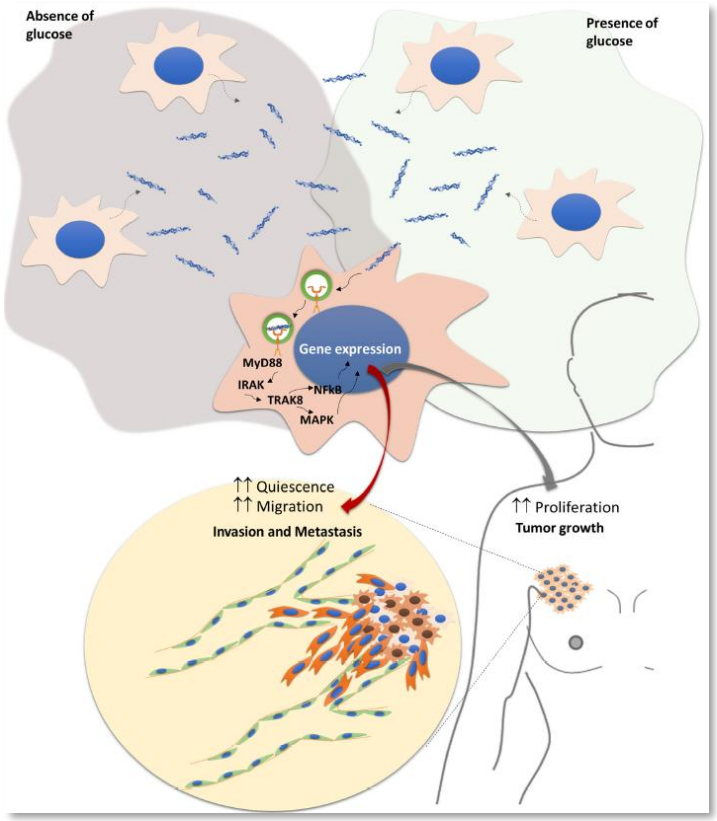
ATP
Pyr
FERM
RESP
LTI





metabolites
MDPI
Article

Cell-Free DNA (cfDNA) Regulates Metabolic Remodeling in the ES-2 Ovarian Carcinoma Cell Line, Influencing Cell Proliferation, Quiescence, and Chemoresistance in a Cell-of-Origin-Specific Manner

Isabel Lemos [1,2], Catarina Freitas-Dias [1,2], Ana Hipólito [1,2], José Ramalho [1], Fabrizio Carteni [3], Luís G. Gonçalves [4,†], Stefano Mazzoleni [3,†] and Jacinta Serpa [1,2,*,†]

metabolites
MDPI
Article

Cell-Free DNA (cfDNA) Regulates Metabolic Remodeling, Sustaining Proliferation, Quiescence, and Migration in MDA-MB-231, a Triple-Negative Breast Carcinoma (TNBC) Cell Line

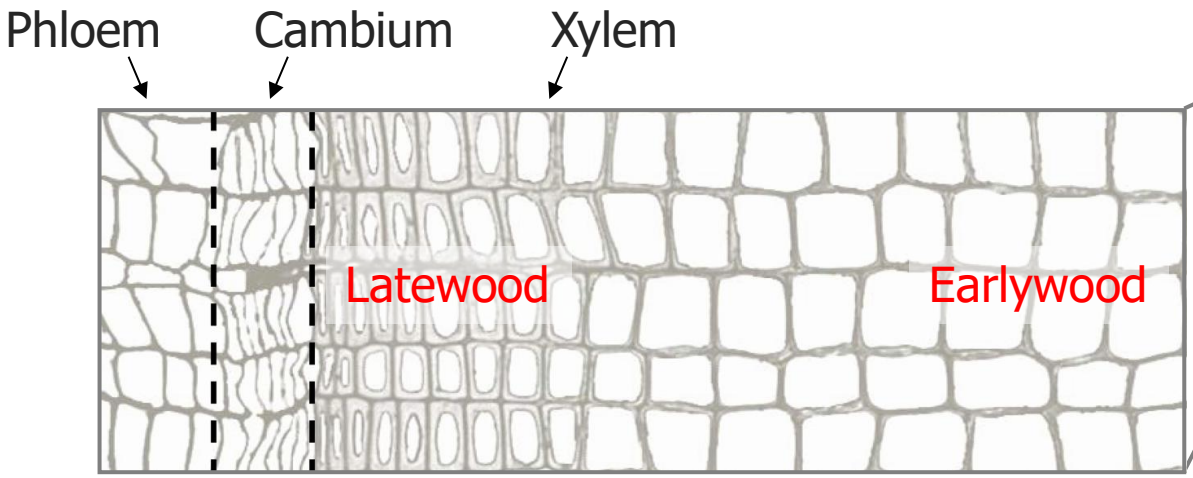
Isabel Lemos [1,2,†], Catarina Freitas-Dias [1,2,†], Ana Hipólito [1,2], José Ramalho [1], Fabrizio Carteni [3], Luís G. Gonçalves [4,‡], Stefano Mazzoleni [3,‡] and Jacinta Serpa [1,2,*,‡]

Xylogenesis (ring formation)

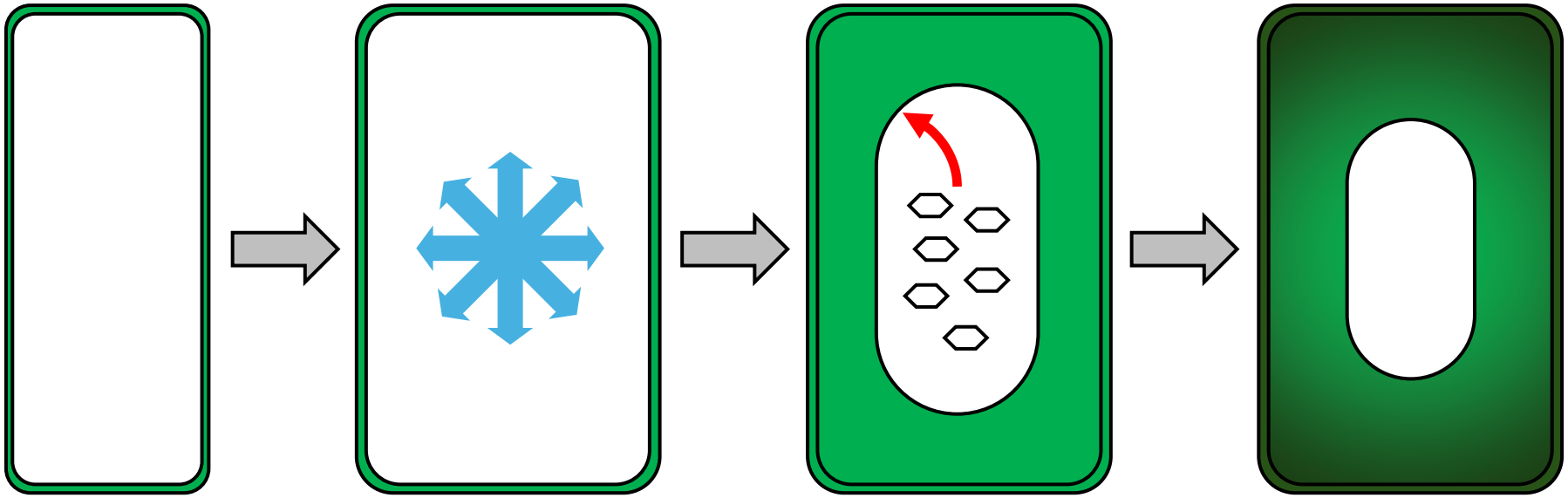
Research question:

What are the factors that can explain

the variation of tracheids anatomical features?



Xylem Development module



Cell enlargement

Wall deposition

Wall lignification

Water availability

Wall elasticity

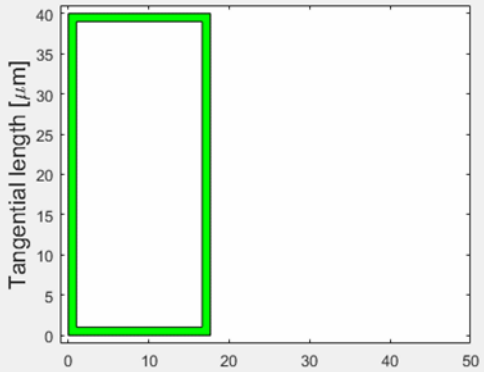
Temperature

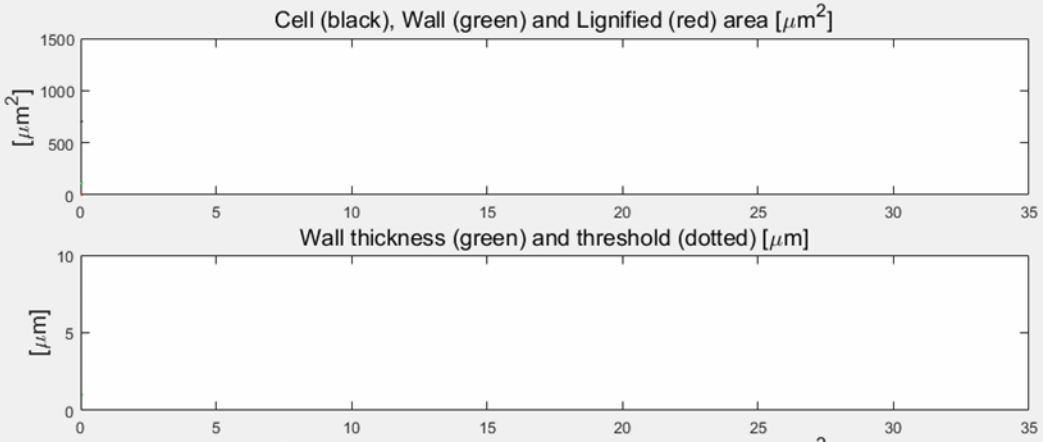
Sugar availability

Temporal dynamics of tracheid development

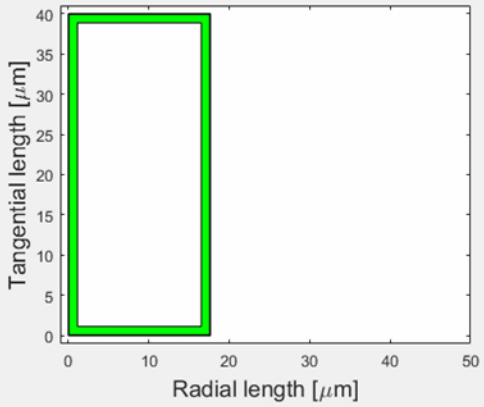
Sugar availability

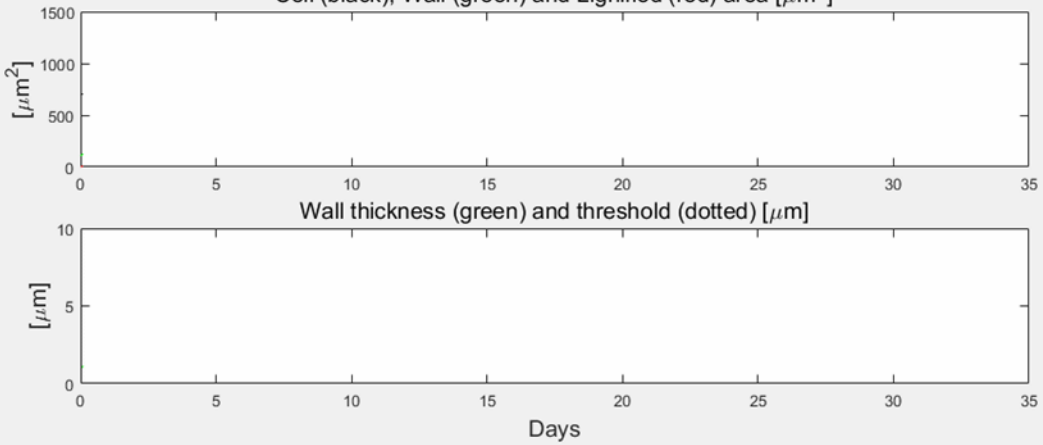
Low





High

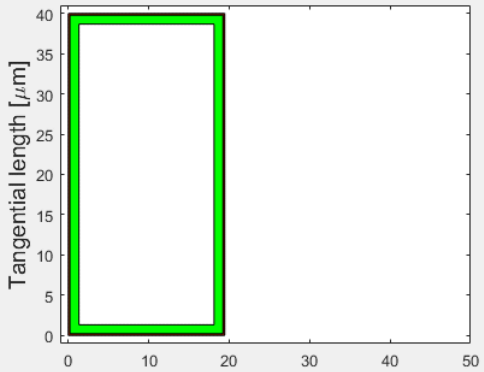


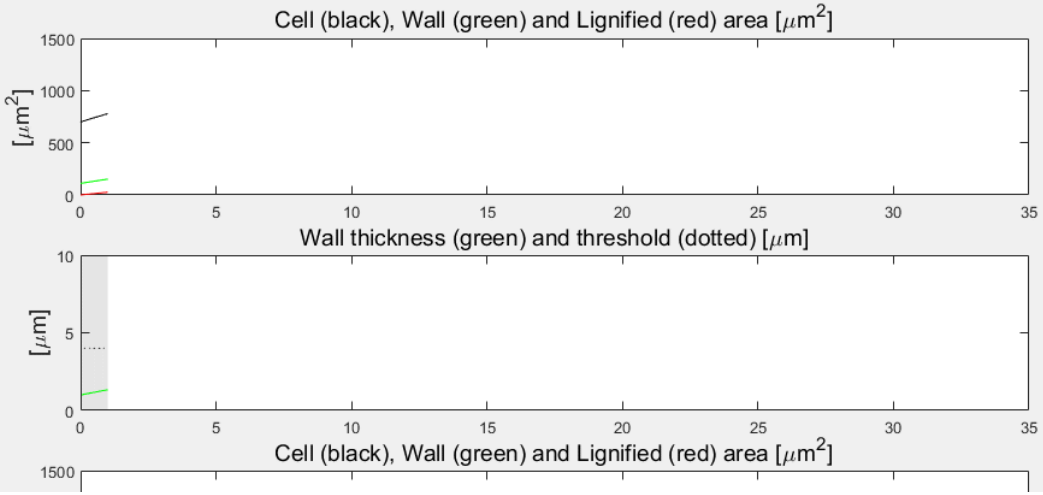


Temporal dynamics of tracheid development

Sugar availability

Low





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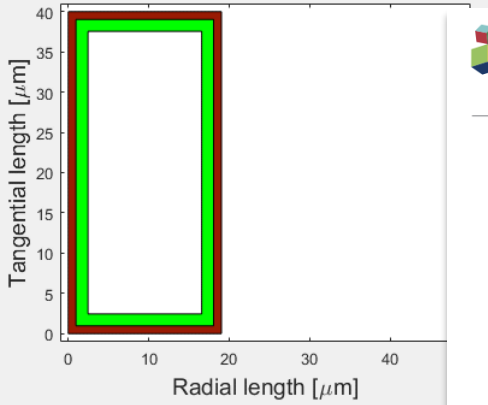

frontiers in Plant Science

ORIGINAL RESEARCH
published: 20 July 2018
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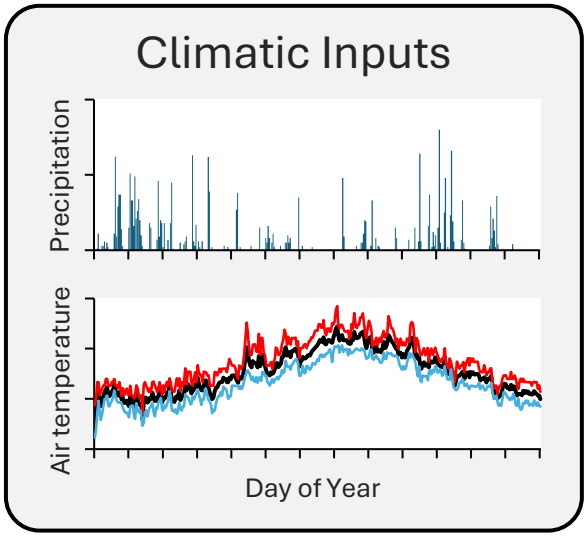
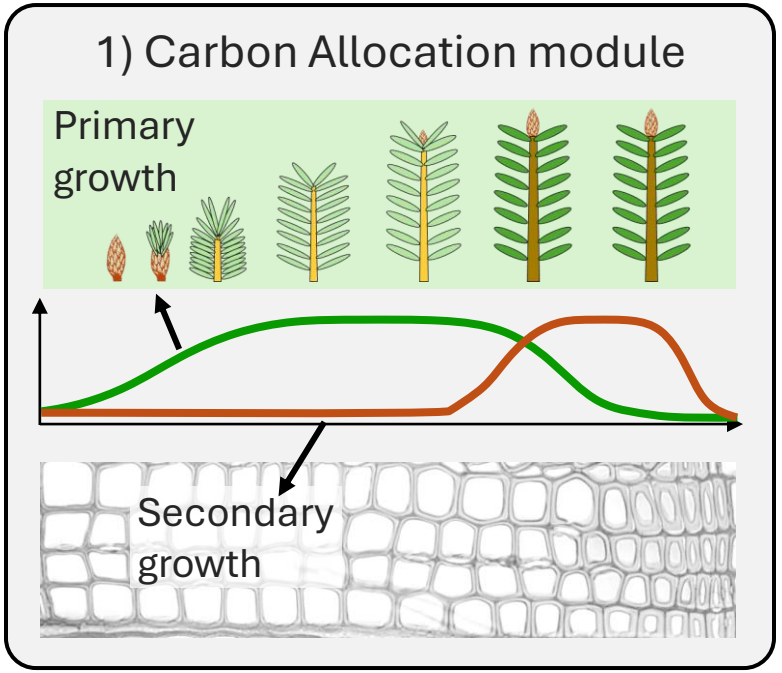
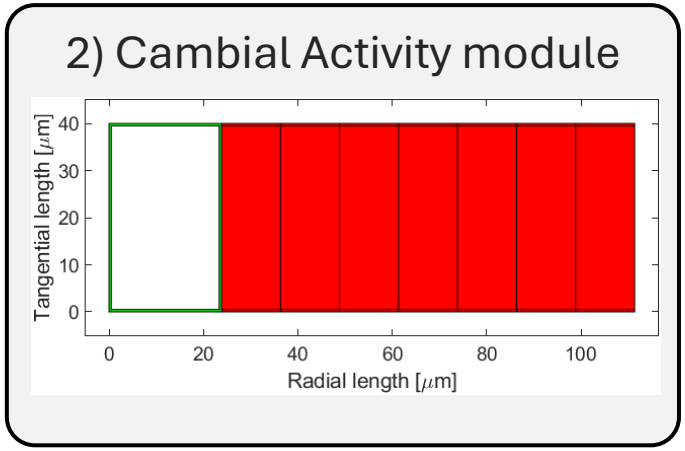
The Physiological Mechanisms Behind the Earlywood-To-Latewood Transition: A Process-Based Modeling Approach

Fabrizio Carteni[1,2], Annie Deslauriers[2], Sergio Rossi[2,3], Hubert Morin[2], Veronica De Micco[1], Stefano Mazzoleni[1] and Francesco Giannino[1]*

Model overview

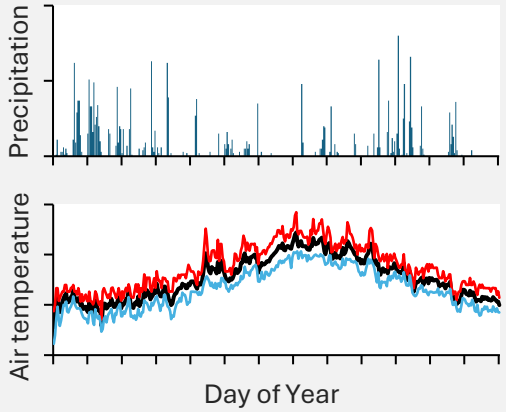




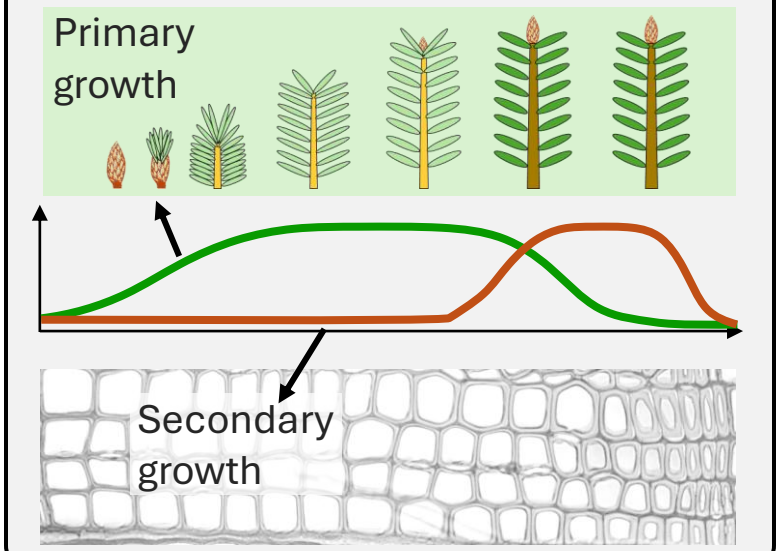


Model overview

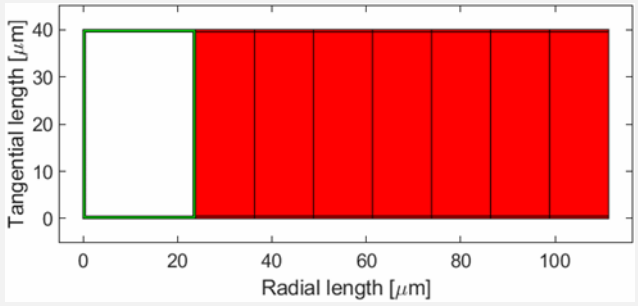
Climatic Inputs



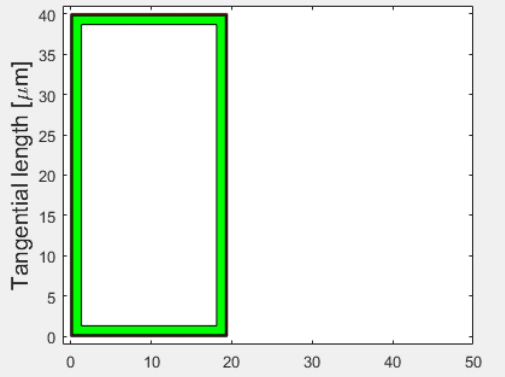
1) Carbon Allocation module



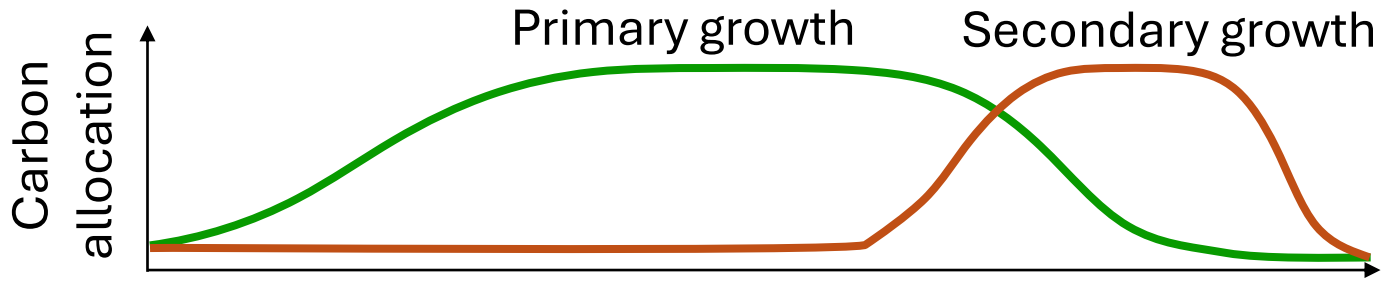
2) Cambial Activity module

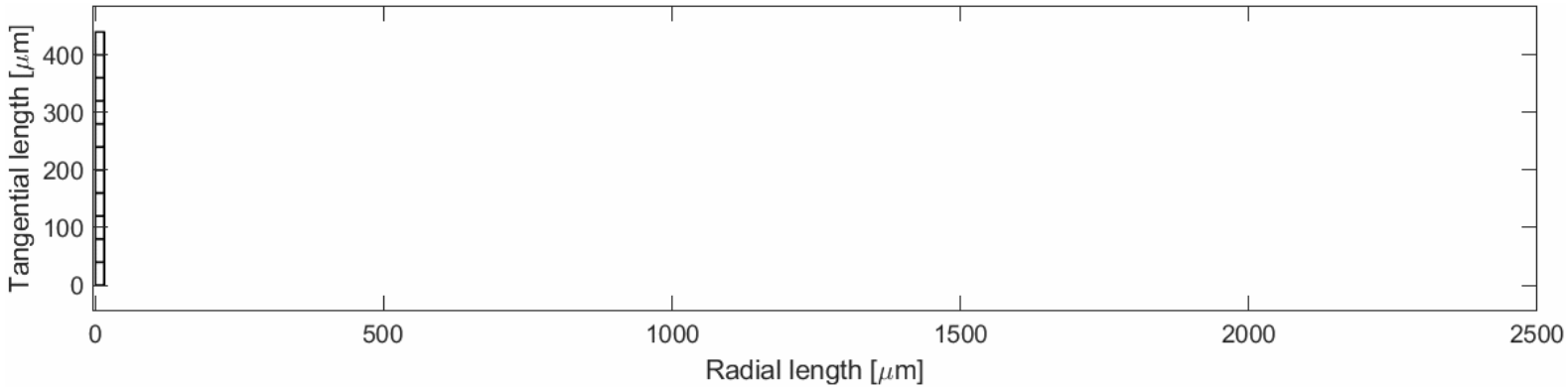


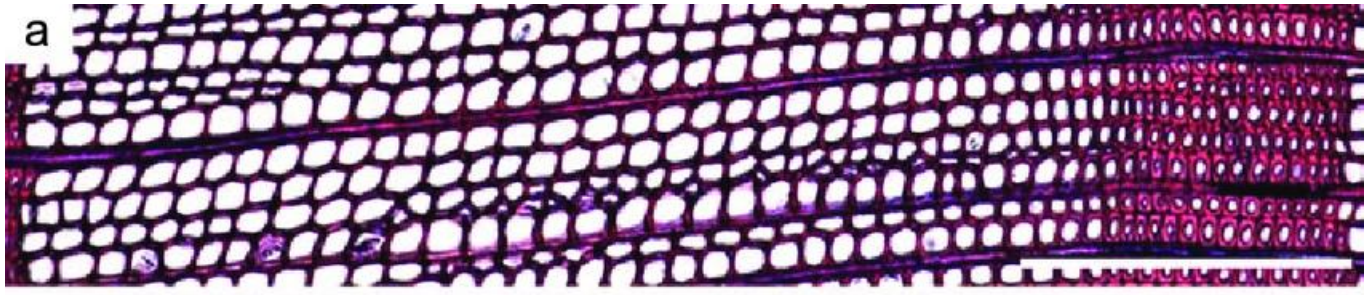
3) Xylem Development module



Simulation of tree ring formation (temperate)

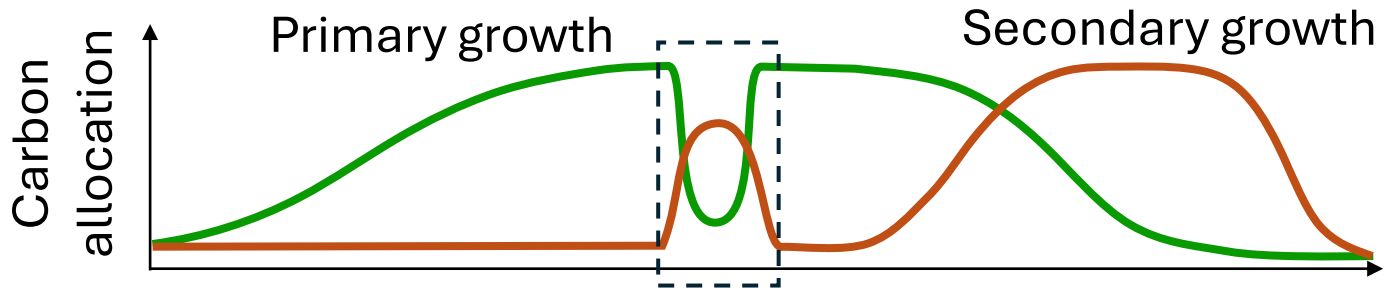


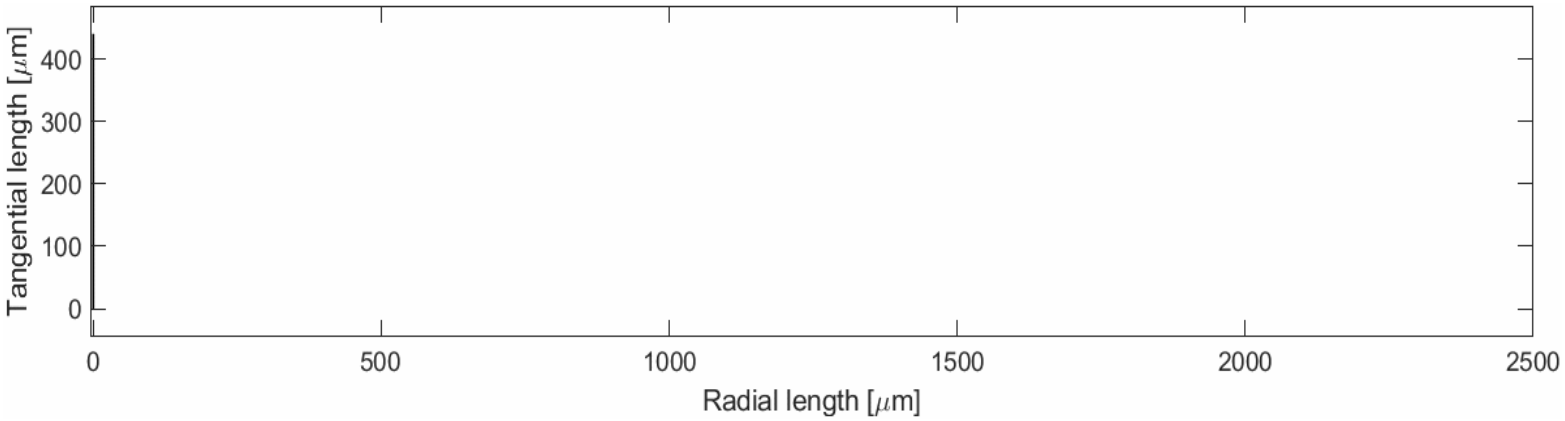




Picture: *Pinus pinea* in Balzano et al. (2018). IAWA Journal. 40. 10.1163/22941932-40190220.

Effect of early summer water stress on tree ring formation





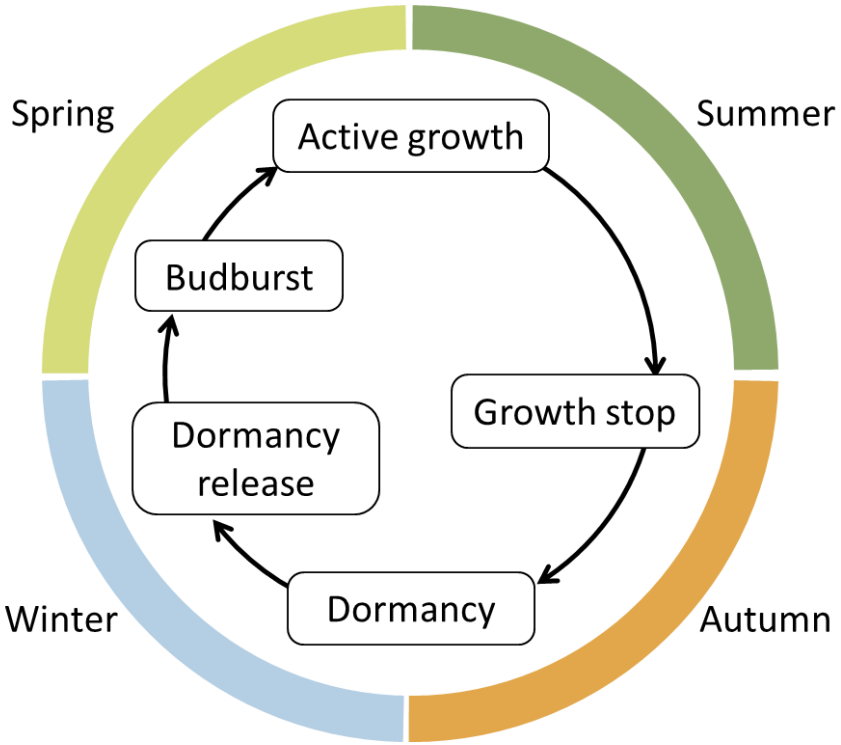
Picture: *Pinus pinaster* (unpublished)

Phenology = timing of seasonal life cycles

Traditional phenological models

- GDD models
(relate phenological processes to environmental driving factors)

- Physiological models
(relate phenology to carbon balance, hormonal status etc.)



Traditional phenological models

Pros:

- simple formulation and easy calibration

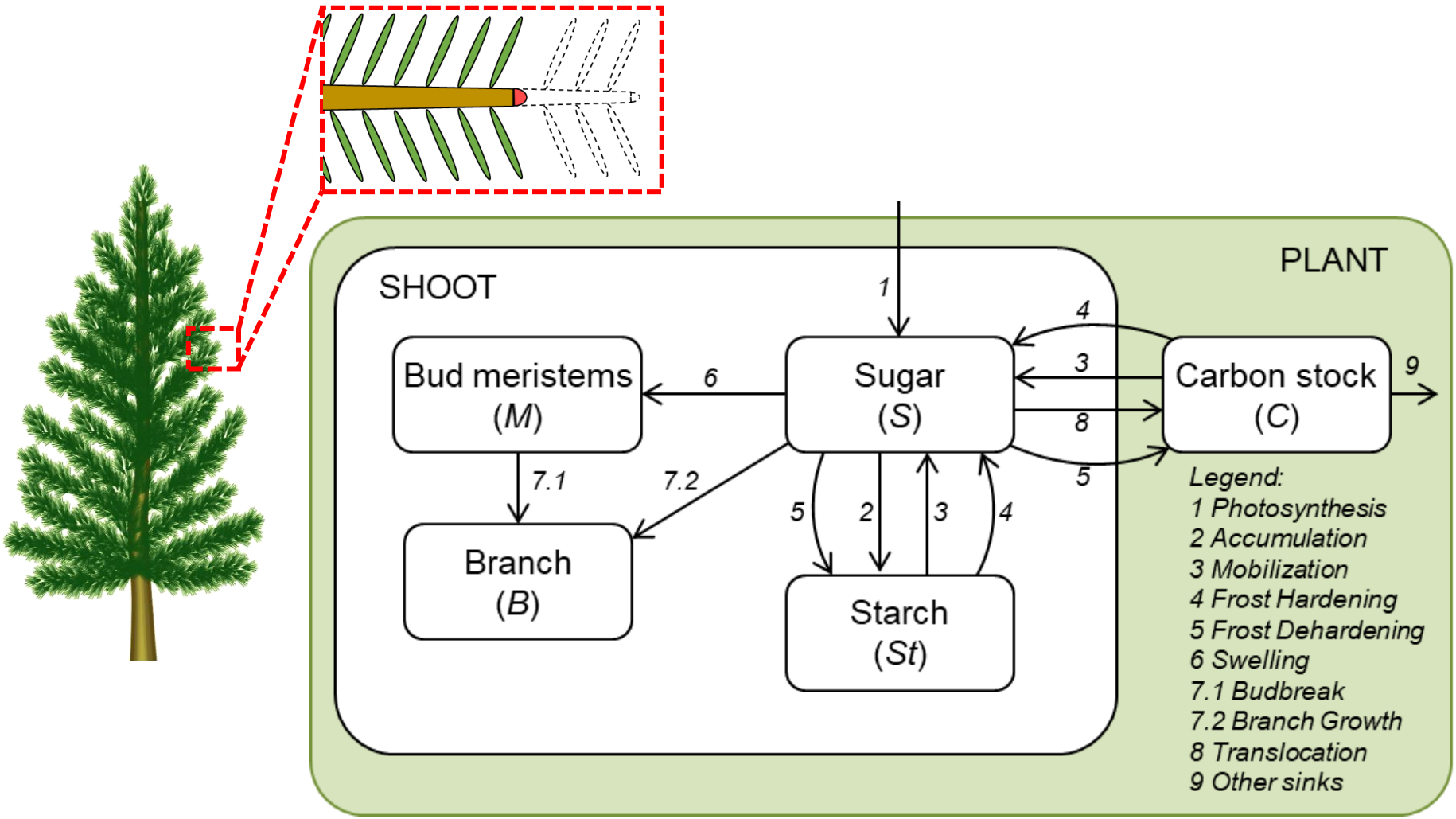
Cons:

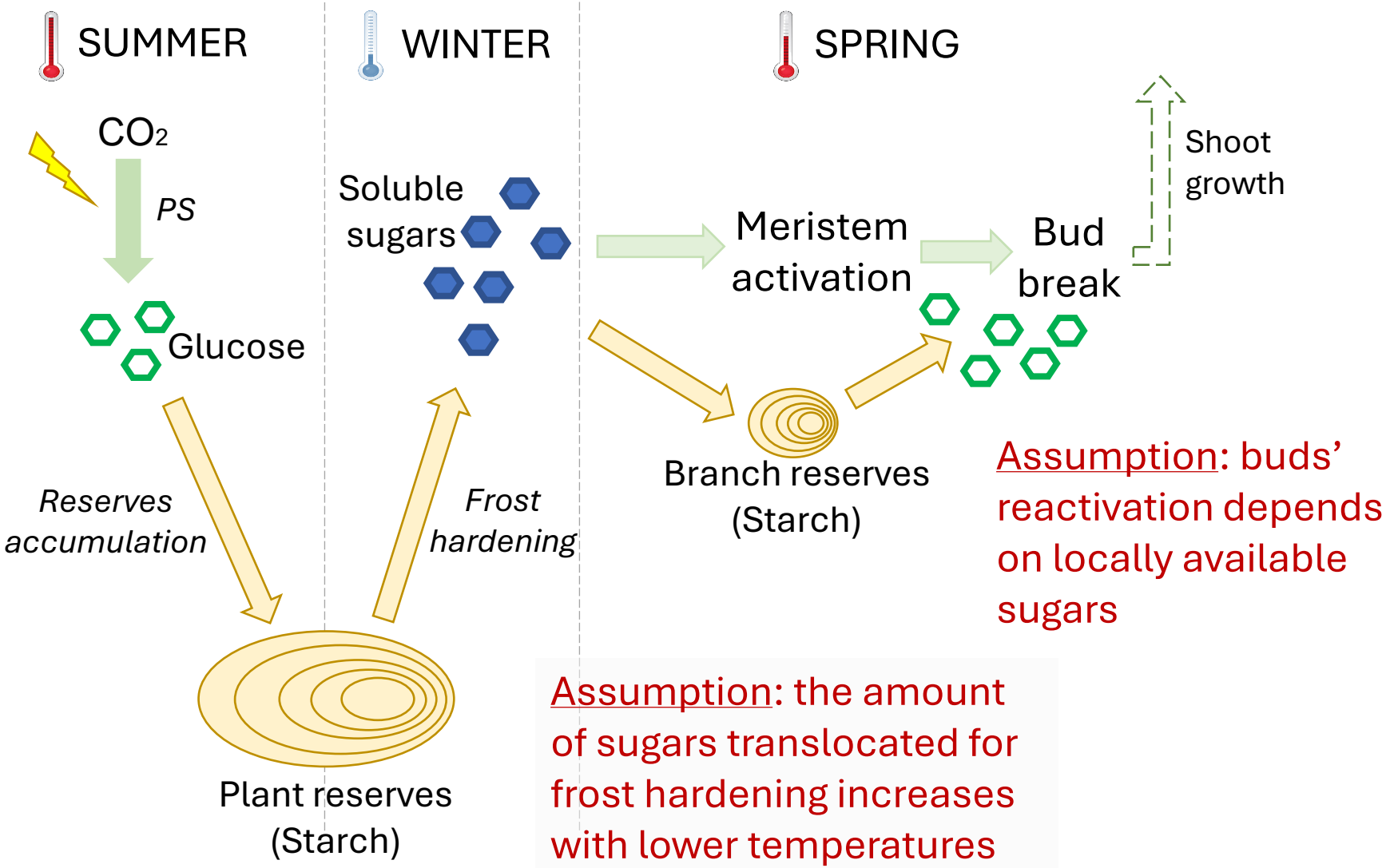
- unrelated to plant growth and physiological status
- calibration not applicable to different sites and climatic conditions

Aim: develop a physiologically-based model

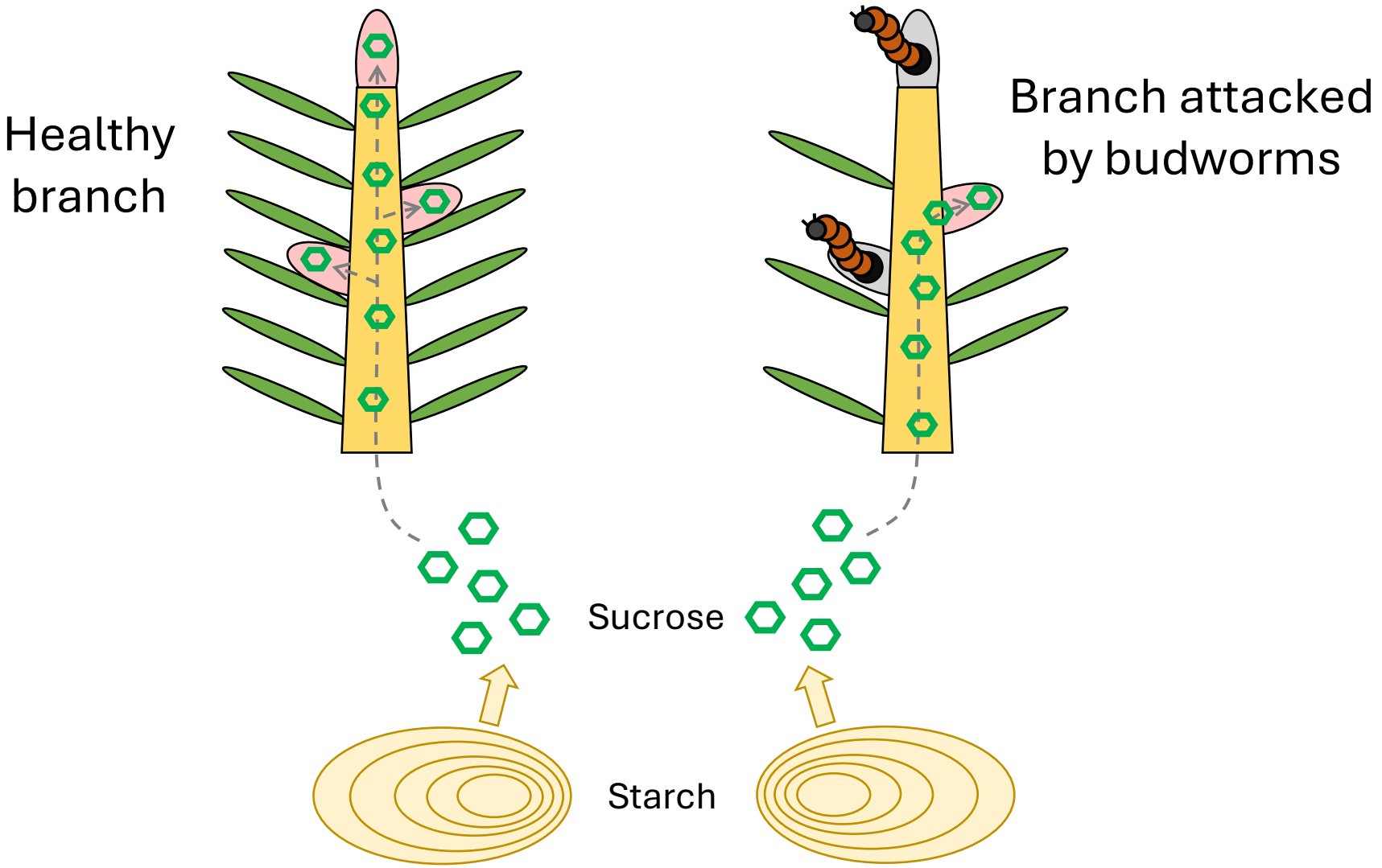
- Coupling phenology to carbon allocation and nutritional status of plants
- Test the effect of climate change and biotic stressors

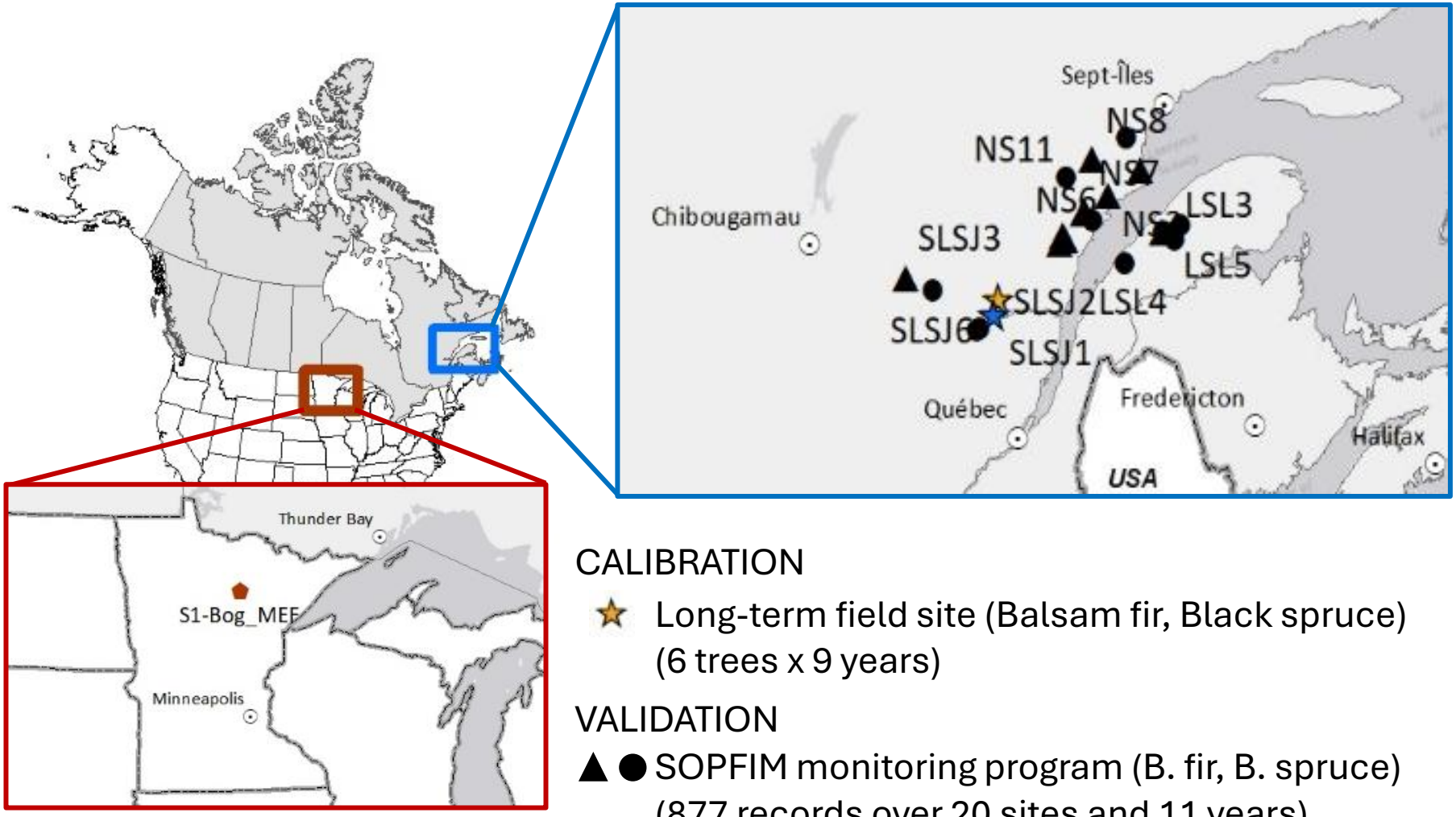
Aim: predict spring phenology of boreal conifers




SUMMER
WINTER
SPRING
CO_2
PS
Glucose
Soluble sugars
Meristem activation
Bud break
Shoot growth
Reserves accumulation
Frost hardening
Branch reserves (Starch)
Plant reserves (Starch)
Assumption: buds' reactivation depends on locally available sugars
Assumption: the amount of sugars translocated for frost hardening increases with lower temperatures

Effect of defoliation on bud phenology





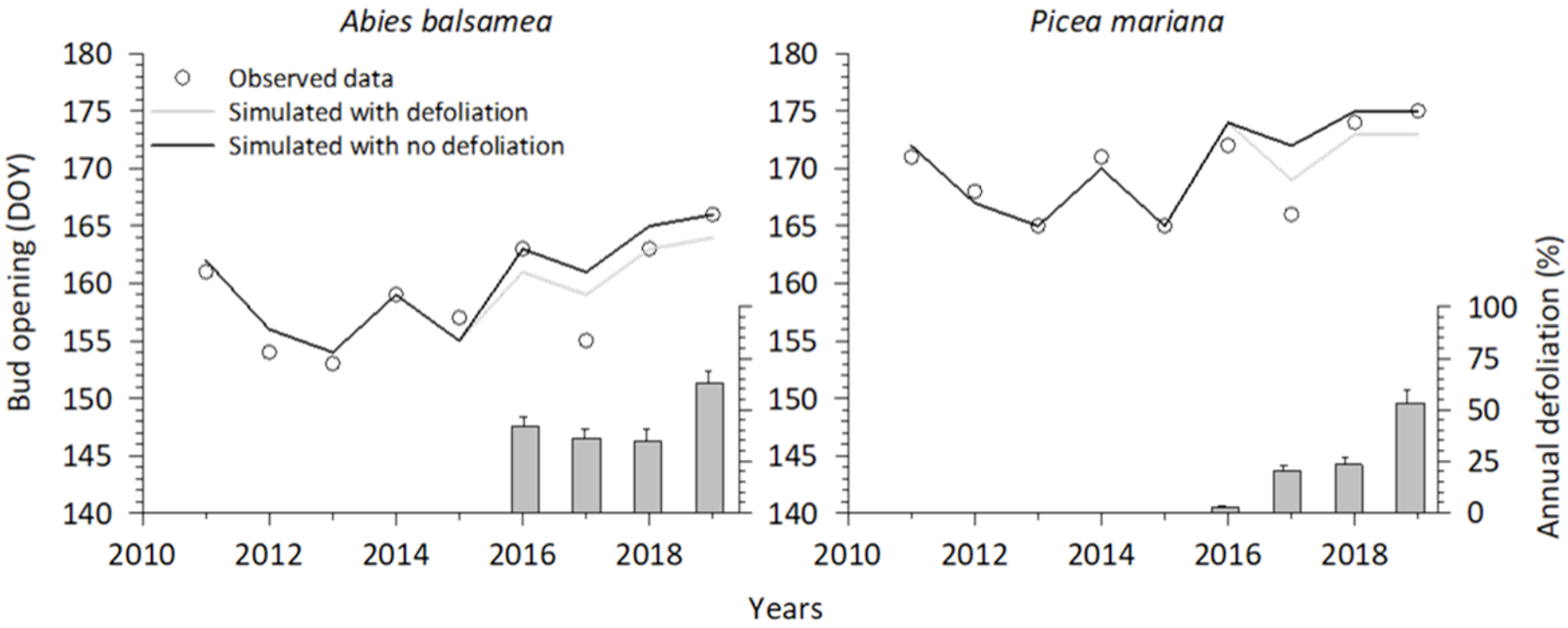
CALIBRATION

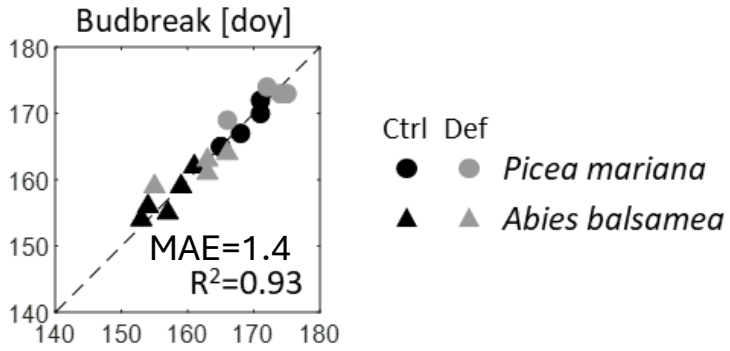
★ Long-term field site (Balsam fir, Black spruce)
(6 trees x 9 years)

VALIDATION

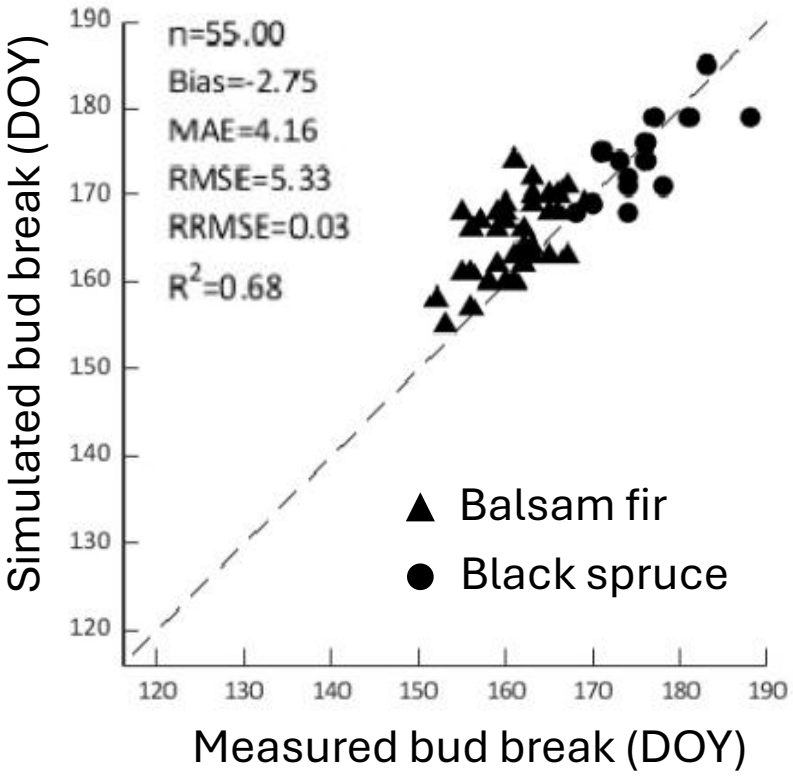
▲ ● SOPFIM monitoring program (B. fir, B. spruce)
(877 records over 20 sites and 11 years)

⬟ SPRUCE experiment (Black spruce)
(11 plots for 5 years)
https://mnspruce.ornl.gov

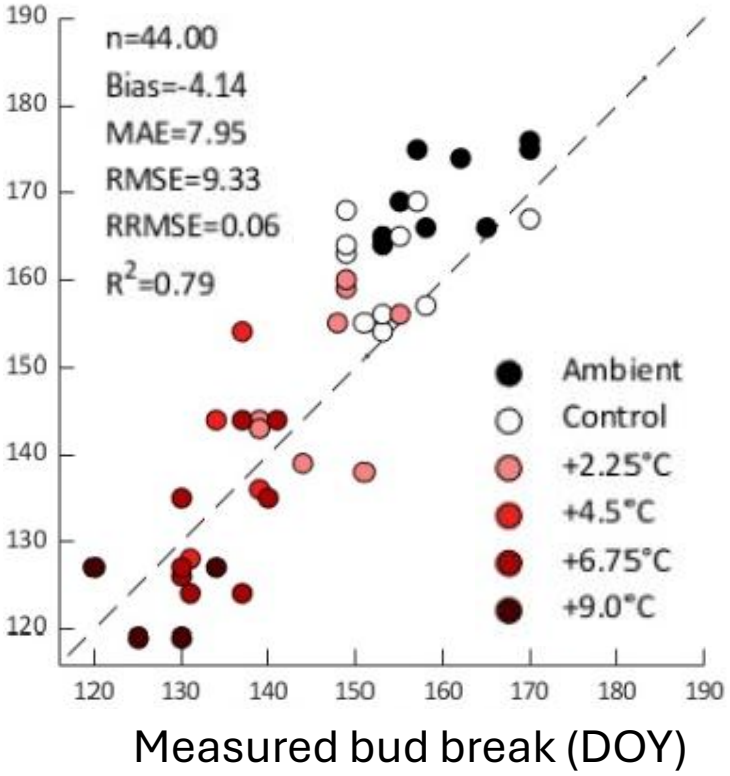

Abies balsamea
Picea mariana
Observed data
Simulated with defoliation
Simulated with no defoliation
Bud opening (DOY)
Annual defoliation (%)
Years
180
175
170
165
160
155
150
145
140
2010
2012
2014
2016
2018
100
75
50
25
0


Budbreak [doy]
MAE=1.4
R²=0.93
Ctrl Def
Picea mariana
Abies balsamea

Quebec (Canada)
SOPFIM dataset



Minnesota (USA)
SPRUCE dataset



Research

New Phytologist

PhenoCaB: a new phenological model based on carbon balance in boreal conifers

Fabrizio Cartenì[1], Lorena Balducci[2], Alain Dupont[3], Emiliano Salucci[1], Valérie Néron[2], Stefano Mazzoleni[1] and Annie Deslauriers[2]

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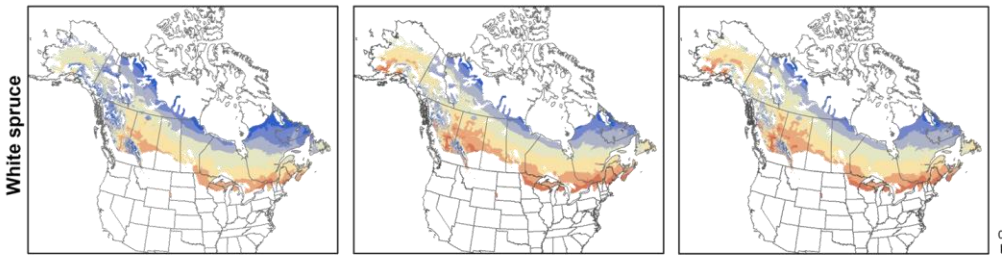
Practical uses:

Study the effect of climate change on boreal forests

Help Canadian forest service to fight pests



New buds = food for defoliators

Defining the timing of insect-host phenology

- Which **species** do we want to protect?
- **When and how** take action – find the best window for aerial **pulverization**

Decision tree: yes/no

Source: http://sopfim.qc.ca/fr/les-arrosages/

Bacillus thuringiensis var. kurstaki

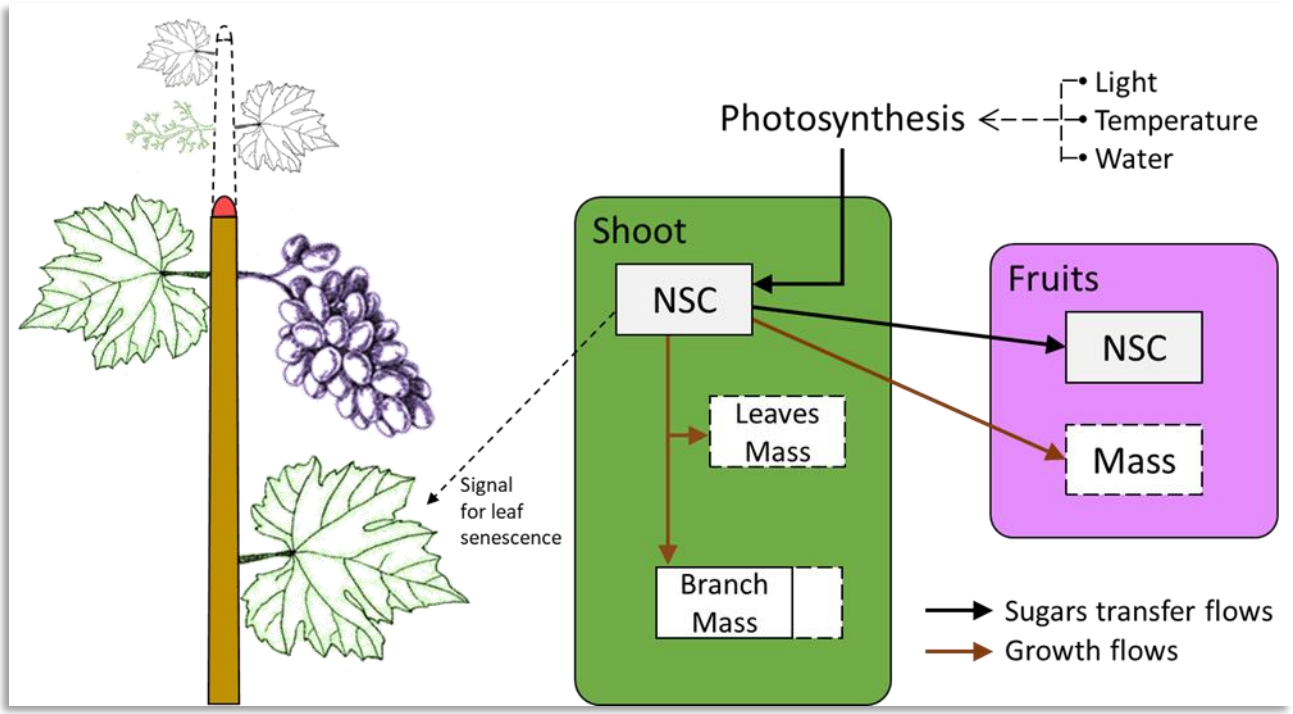
Natural Resources Canada Ressources naturelles Canada
Canada
UQAC UNIVERSITÉ DU QUÉBEC À CHICOUTIMI
Forêts, Faune et Parcs Québec
SOPFIM Société de protection des forêts contre les insectes et maladies

Fenologia vegetativa e riproduttiva della vite

H2020

VISCA
VINEYARDS INTEGRATED SMART CLIMATE APPLICATION

VITIGEOSS



Carteni F, Rossi C, Marcos R, Porras I, Basile B, Scognamiglio P, et al., editors. LEAF: A process-based model of berry ripening in vineyards. 2019 IEEE International Workshop on Metrology for Agriculture and Forestry, MetroAgriFor 2019 - Proceedings; 2019: IEEE.

Grazie per l'attenzione!

Prossimo seminario:

15 ottobre 2025 (Aula magna DMVPA)

Laura Rinaldi

Approcci multidisciplinari in parassitologia