in the news …

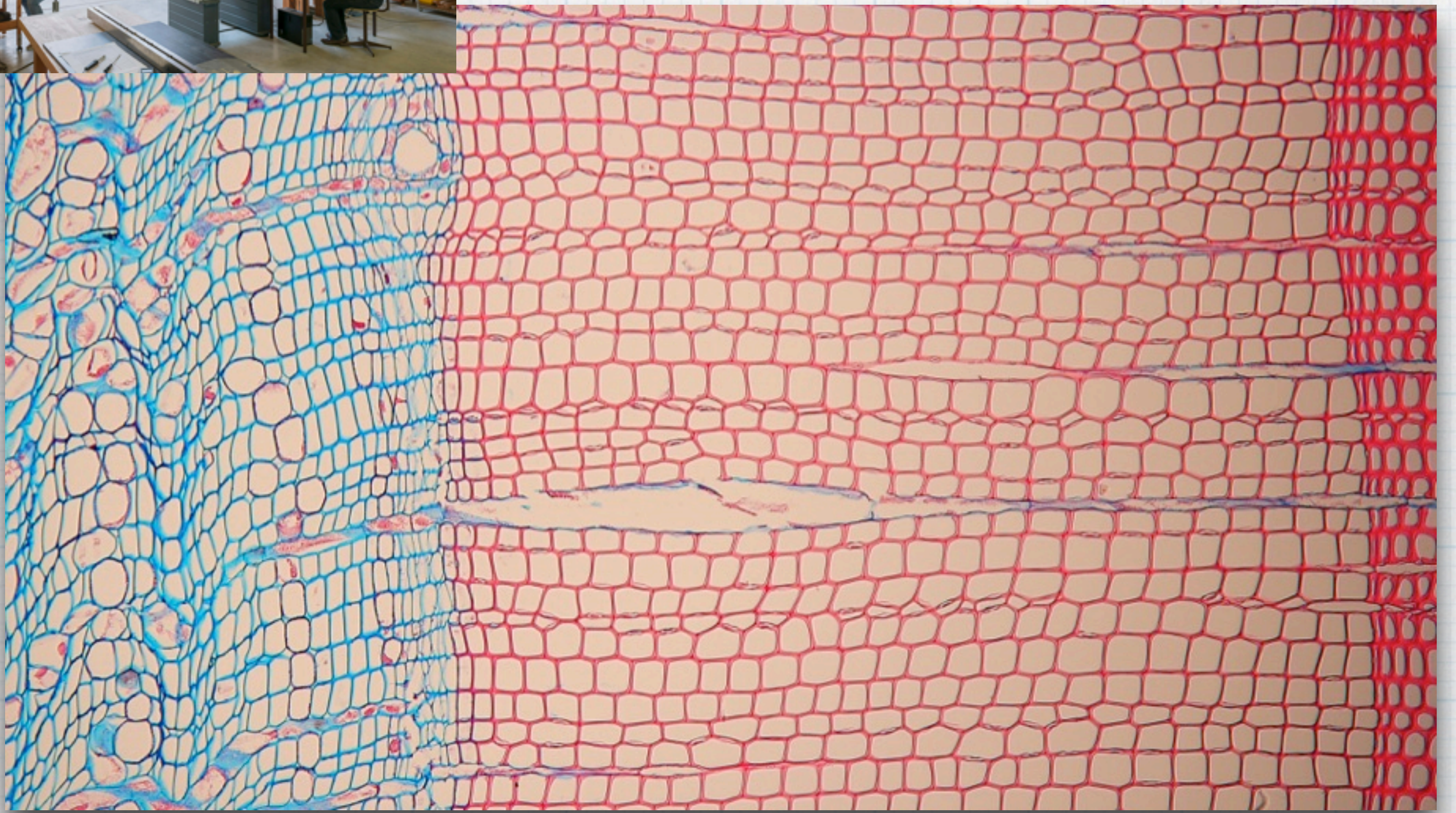
Climate change is making the wood lighter

Manuela Casasoli ‣ SCIENCE Aug 22, 2018

*As global temperatures rise, **trees around the world are experiencing longer growing seasons**, sometimes as much as three extra weeks a year. All that time helps trees grow faster. But **a study of the forests of Central Europe suggests the higher temperatures—combined with pollution from auto exhaust and farms—are making wood weaker**, resulting in trees that break more easily and lumber that is less durable.*

Pretzsch *et al.* (2018) ***Wood density reduced while wood volume growth accelerated in Central European forests since 1870***.
https://www.sciencedirect.com/science/article/pii/S0378112718310600?via%3Dihub

Climate change is making trees bigger, but weaker

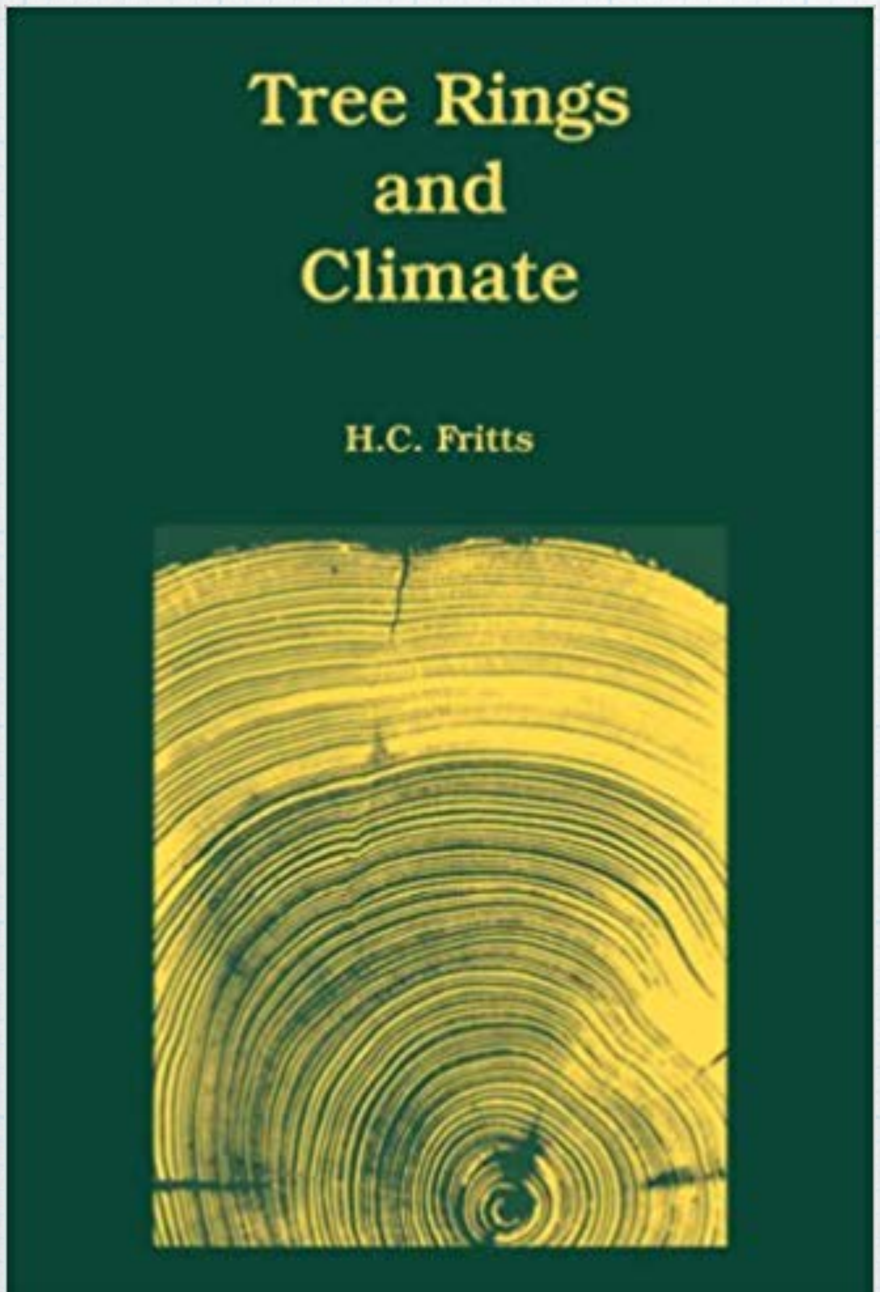


Impact du changement climatique sur la formation du bois

Patrick Fonti

Institut fédéral de recherches sur la forêt, la neige et le paysage WSL

Climate impact



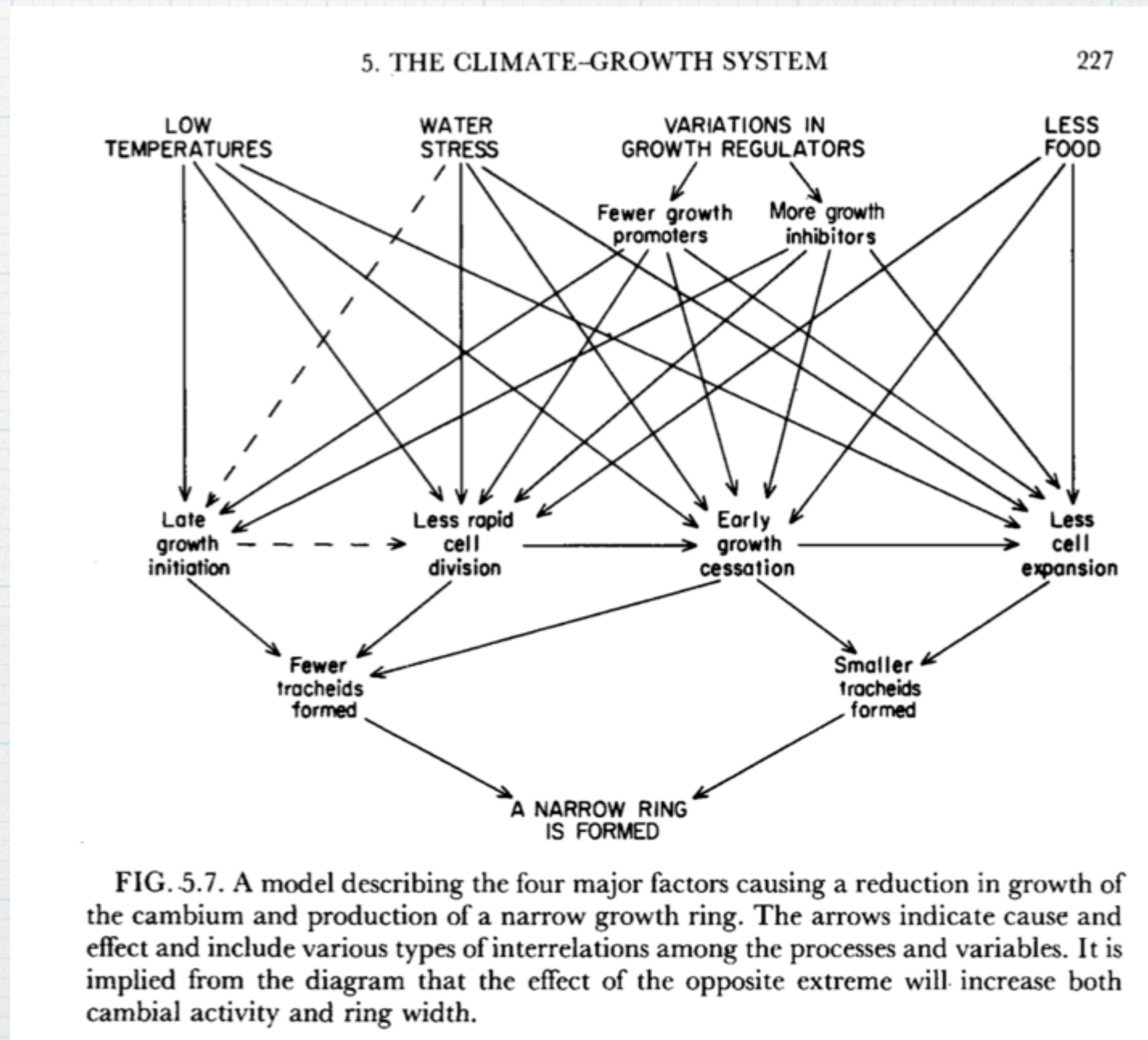


FIG. 5.7. A model describing the four major factors causing a reduction in growth of the cambium and production of a narrow growth ring. The arrows indicate cause and effect and include various types of interrelations among the processes and variables. It is implied from the diagram that the effect of the opposite extreme will increase both cambial activity and ring width.

Dendroclimatology

REPORTS

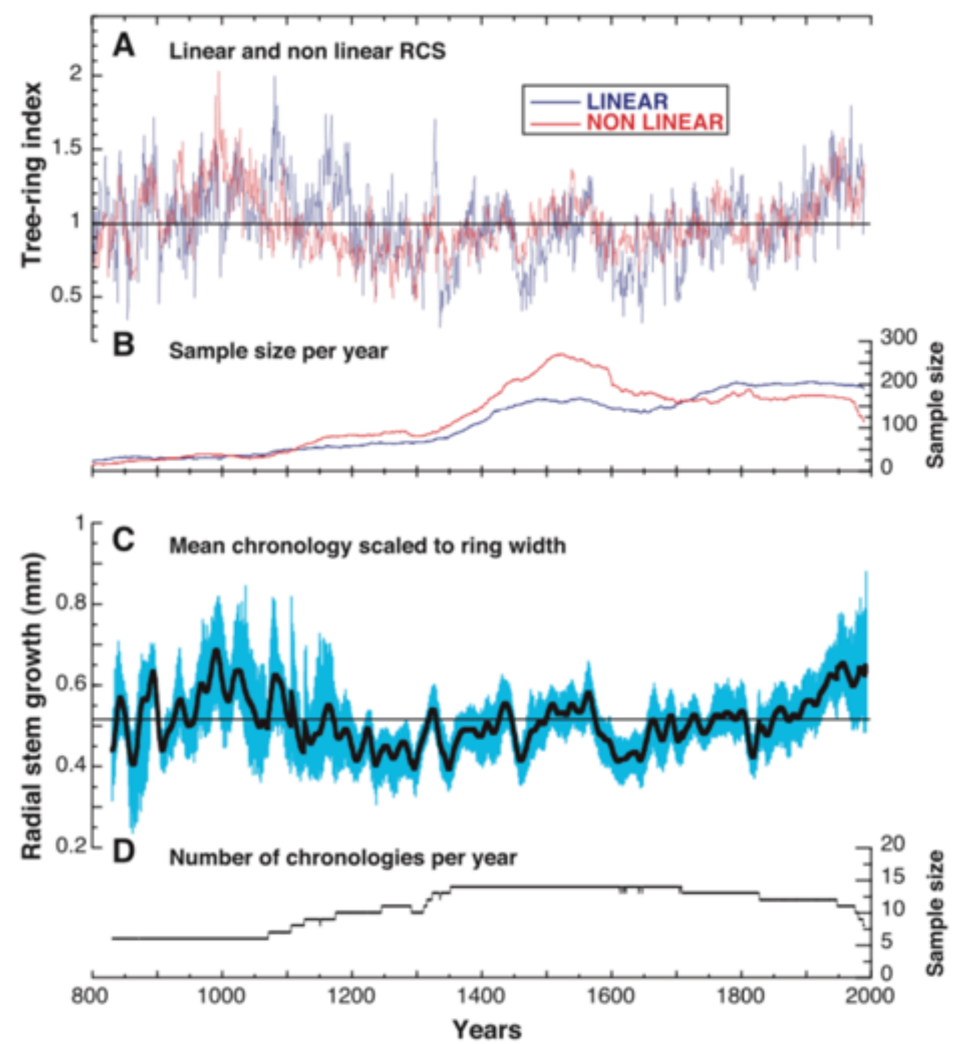
Low-Frequency Signals in Long Tree-Ring Chronologies for Reconstructing Past Temperature Variability

Jan Esper,[1] Edward R. Cook,[2*] Fritz H. Schweingruber[1]

Preserving multicentennial climate variability in long tree-ring records is critically important for reconstructing the full range of temperature variability over the past 1000 years. This allows the putative "Medieval Warm Period" (MWP) to be described and to be compared with 20th-century warming in modeling and attribution studies. We demonstrate that carefully selected tree-ring chronologies from 14 sites in the Northern Hemisphere (NH) extratropics can preserve such coherent large-scale, multicentennial temperature trends if proper methods of analysis are used. In addition, we show that the average of these chronologies supports the large-scale occurrence of the MWP over the NH extratropics.

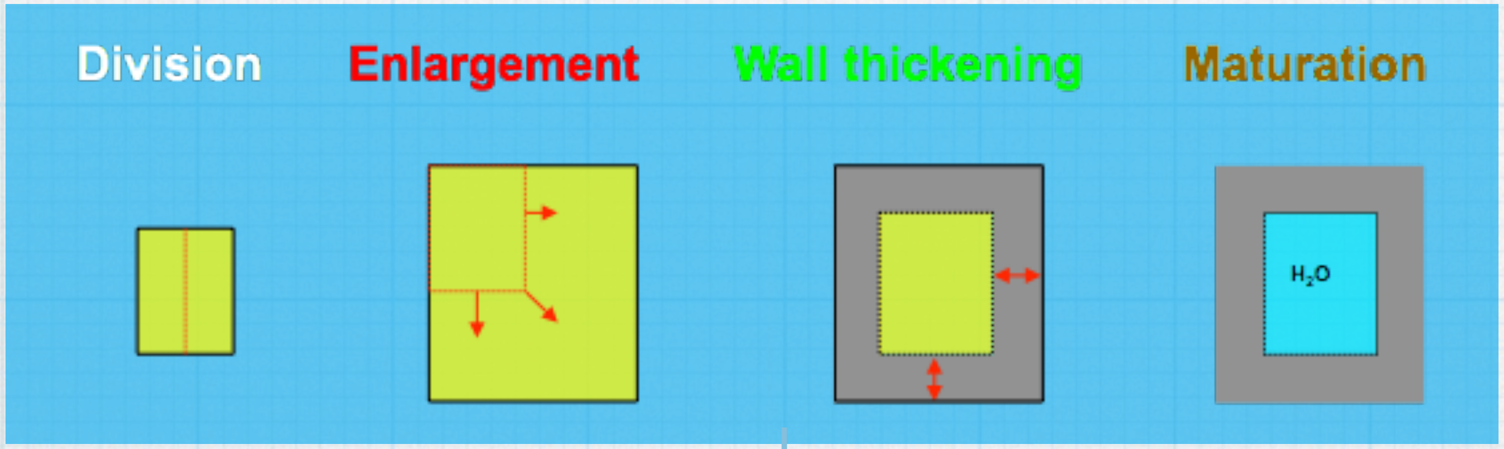
These growth trends occur almost universally in "raw" tree-ring measurement series and frequently describe a downward trend of ring width with increasing age. Dendrochronologists usually eliminate these growth trends by detrending each tree-ring width series with a fitted smooth mathematical growth function. In such cases, the maximum wavelength of recoverable climatic information is fundamentally limited by the segment lengths of the individual detrended series (*7*). Thus, a 100-year-long tree-ring series will not contain any climatic variance at periods longer then 100 years if it is explicitly detrended by a fitted growth curve. Consequently, the problem of missing long-term trends in millennia-length tree-ring chronologies is due to using detrended series that are short relative to the multicentennial fluctuations due to climate (*8*). Exceptions are chronologies built with 1000 year or longer individual tree-ring series (*9*, *10*) and chronologies developed by Regional Curve Standardization

Fig. 2. RCS chronologies of linear and nonlinear classified trees (**A**), the yearly sample size for each chronology (**B**), the 20-year smoothed NH extratropics reconstruction of radial stem productivity in high elevation and high latitude forest environments since ~800 (black) and two-tailed 95% bootstrap confidence intervals (blue) (**C**), and the number of chronologies available for the reconstruction each year (**D**). The NH reconstruction was derived from the 14 site RCS chronologies after each was smoothed with a 20-year low-pass filter to emphasize multidecadal to multicentennial time scales. The two-tailed 95% confidence limits were estimated with the use of a bootstrap procedure (*8*).



The fundamentals

Climate change
weather



wood structure

functioning

performance/survival

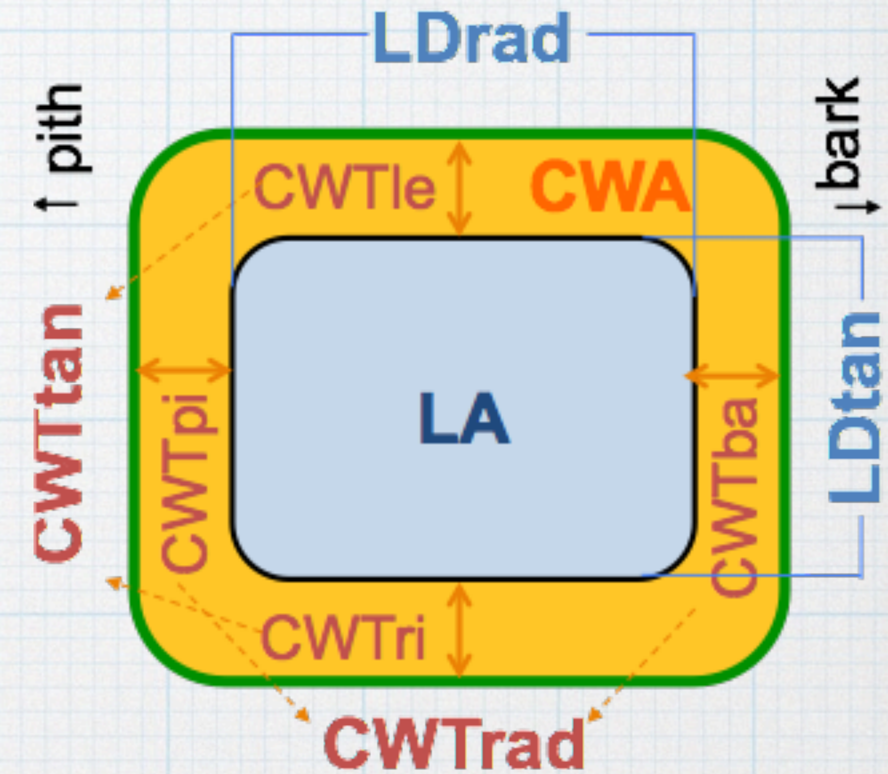
wood properties

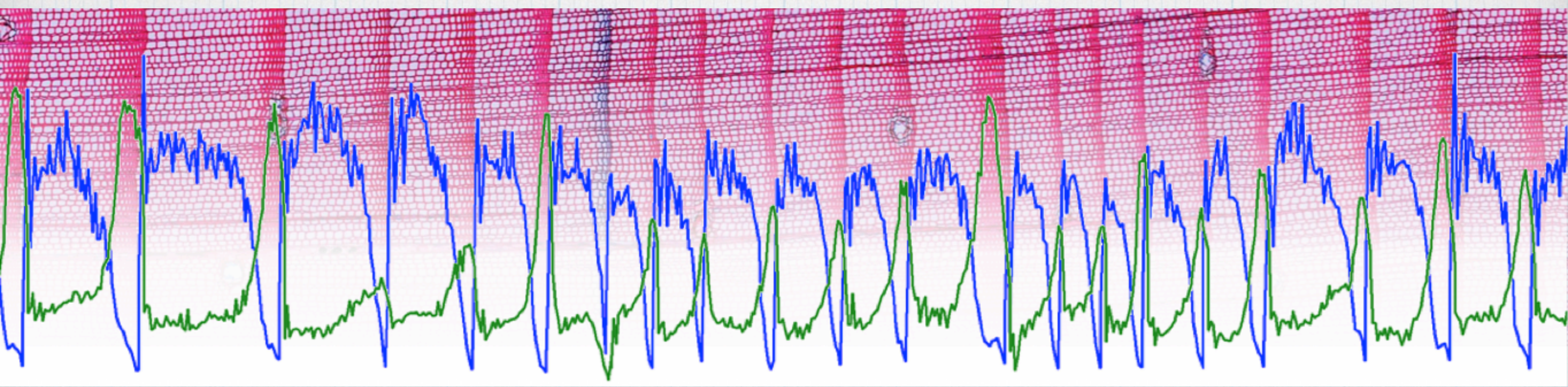
Two ways to investigate climate -> structure

* 1. Tree-ring anatomy (retrospectively)
* 2. Xylogenesis (observations "live")

1. Tree-ring anatomy

* Linking climatic/environmental variability to dated time series of cell anatomical features

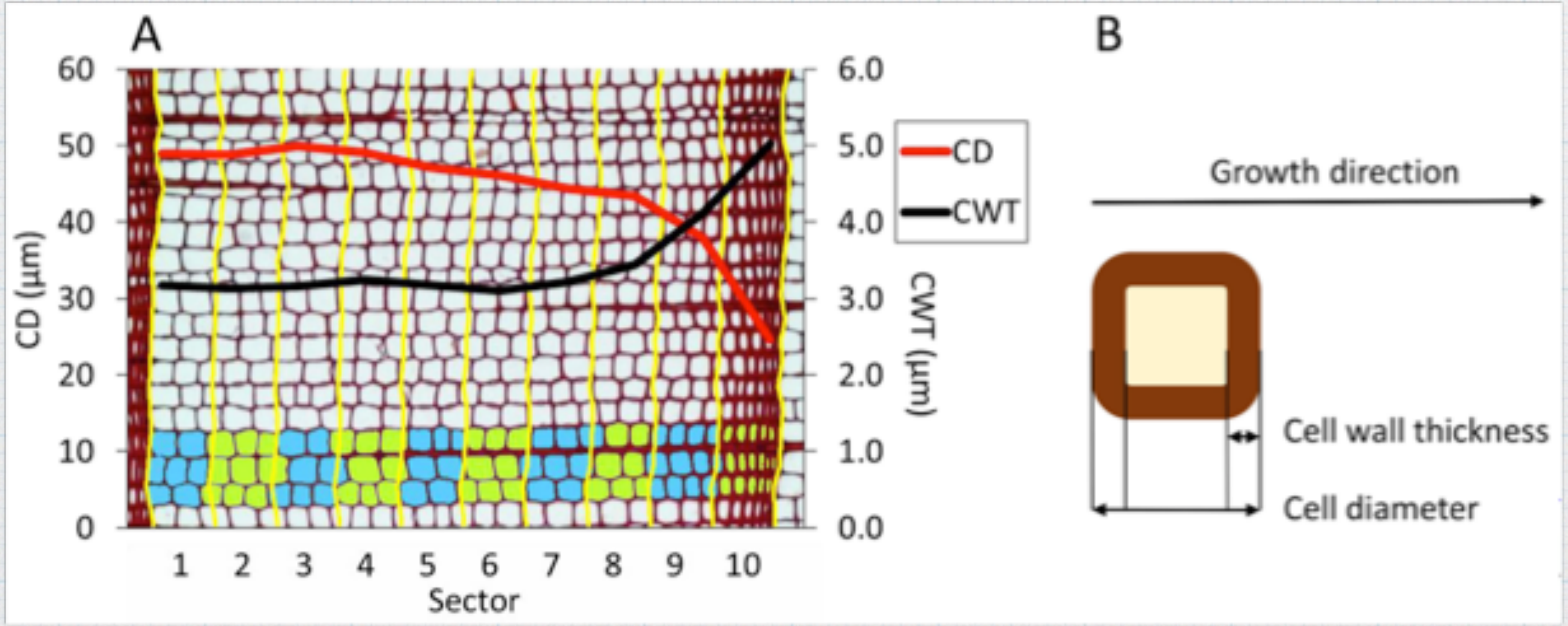


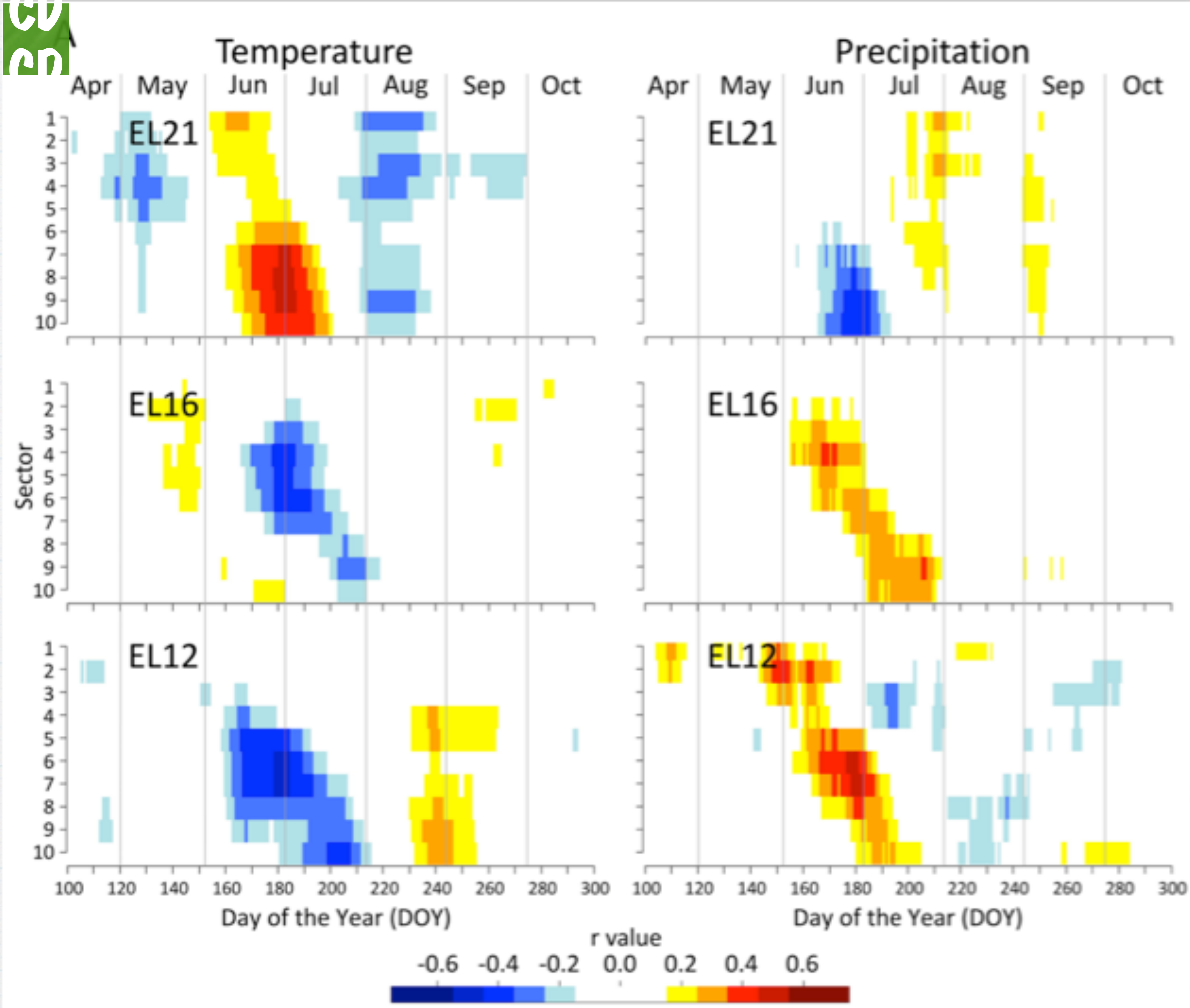


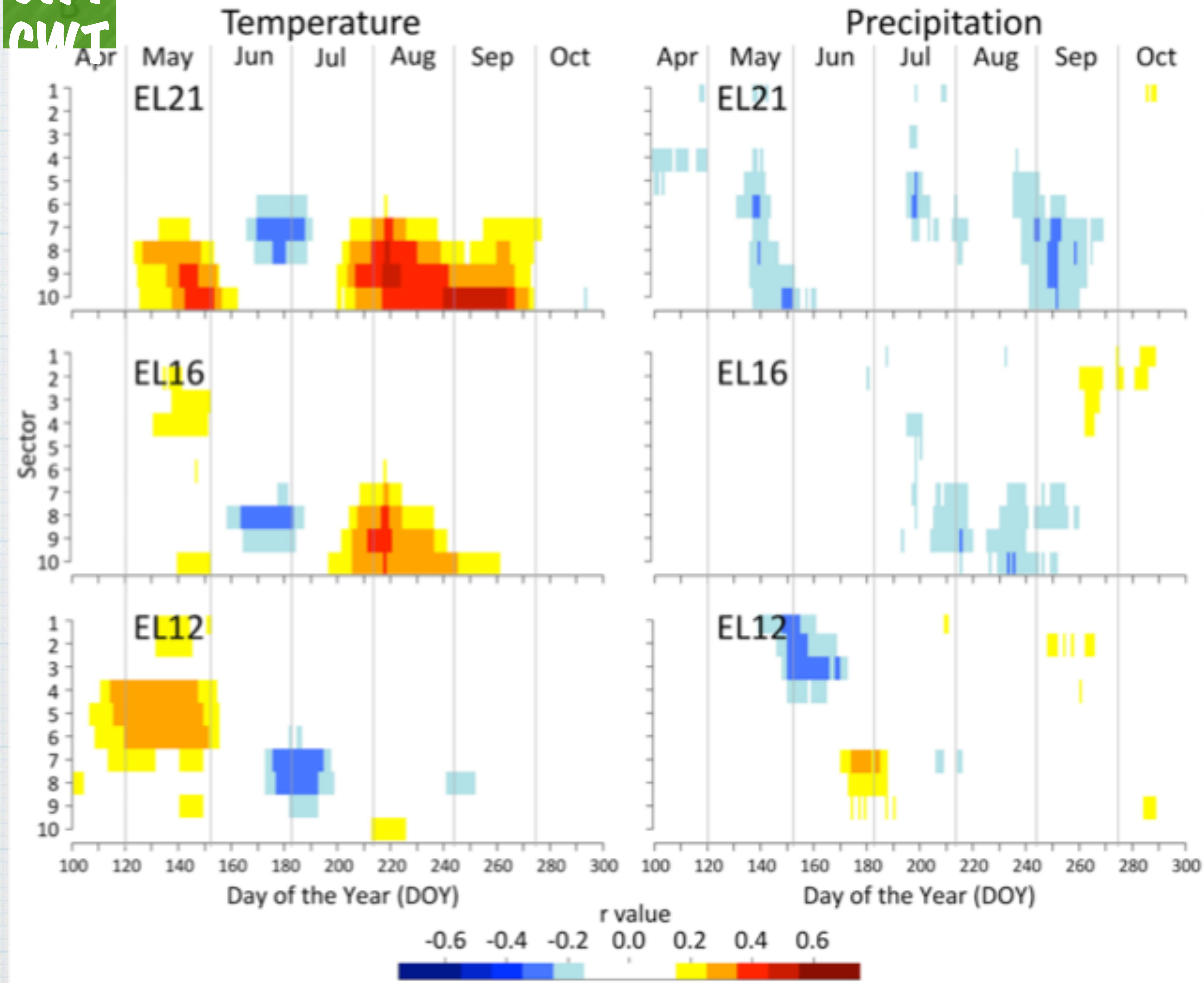
Example
Castagneri et al 2017

Long-term high-resolution signal

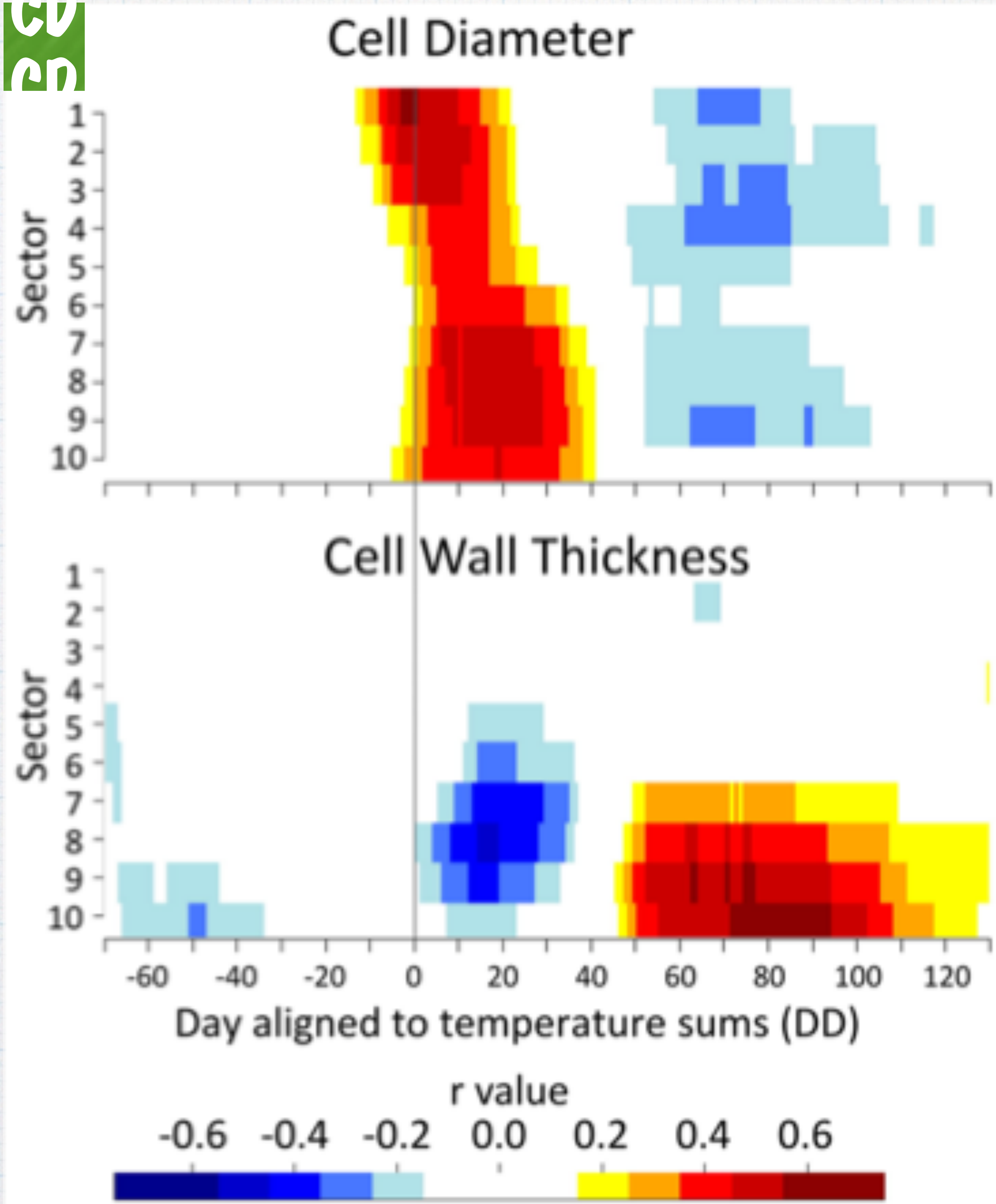
24 *Picea abies*
3 elevations (1200, 1600, 2100)
86 annual rings
CD vs CWT



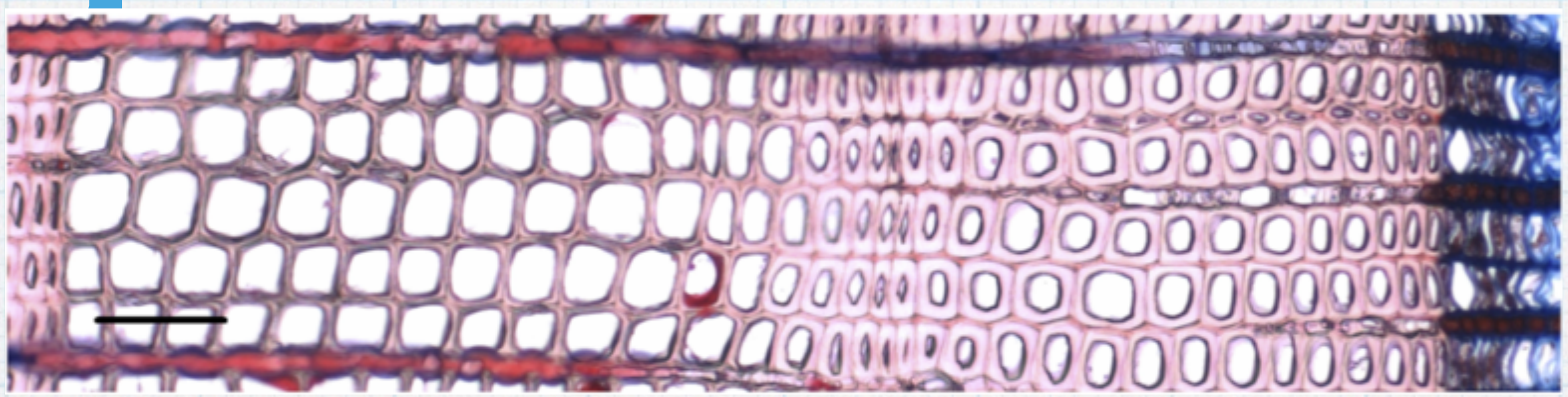

A
Temperature
Precipitation
Apr May Jun Jul Aug Sep Oct
EL21
EL16
EL12
Sector
1 2 3 4 5 6 7 8 9 10
100 120 140 160 180 200 220 240 260 280 300
Day of the Year (DOY)
r value
-0.6 -0.4 -0.2 0.0 0.2 0.4 0.6


Temperature
Precipitation
Apr
May
Jun
Jul
Aug
Sep
Oct
EL21
EL16
EL12
Sector
Day of the Year (DOY)
100
120
140
160
180
200
220
240
260
280
300
r value
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6

CD


Cell Diameter
Sector
1
2
3
4
5
6
7
8
9
10
Cell Wall Thickness
Sector
1
2
3
4
5
6
7
8
9
10
-60
-40
-20
0
20
40
60
80
100
120
Day aligned to temperature sums (DD)
r value
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6

Example
Popkova et al. 2018



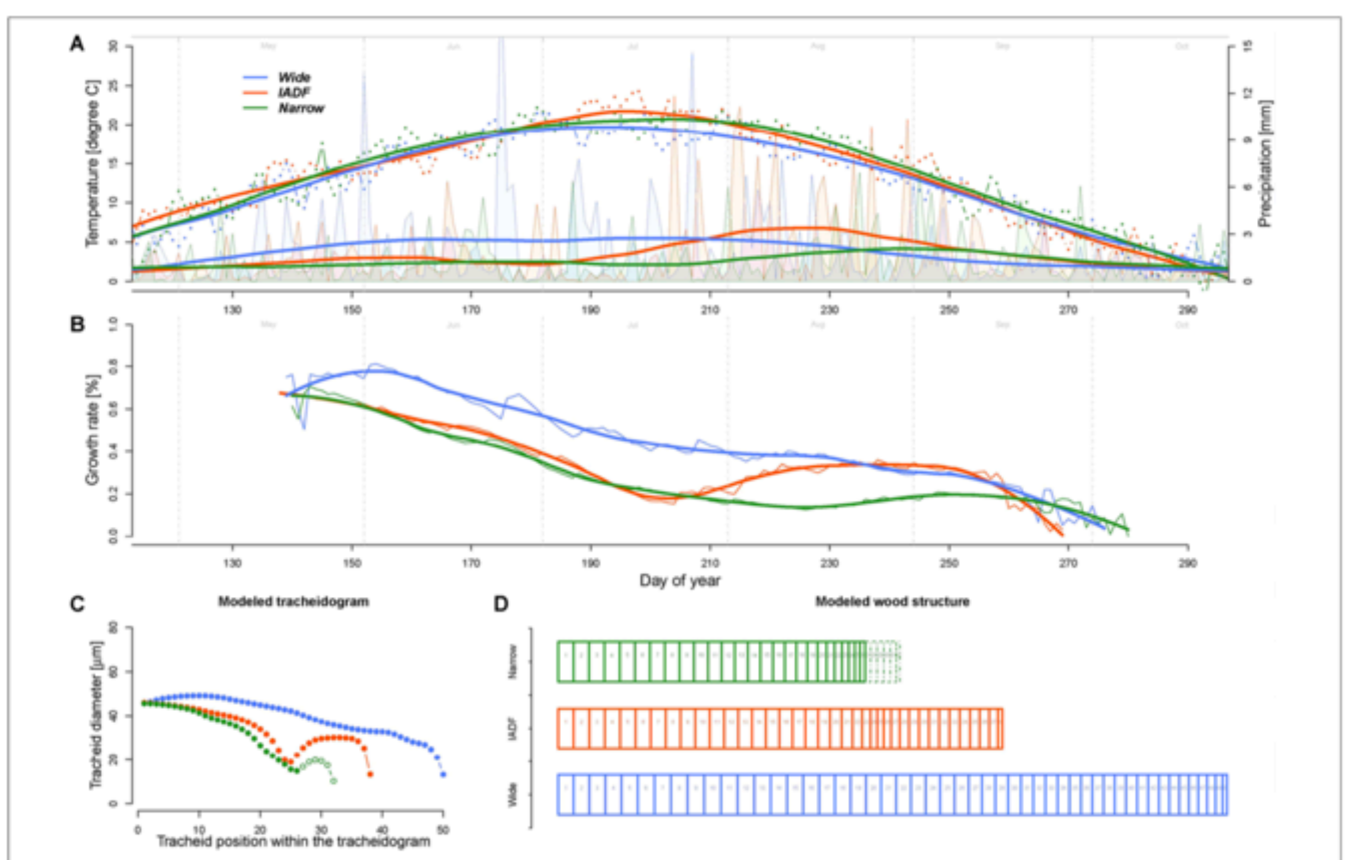
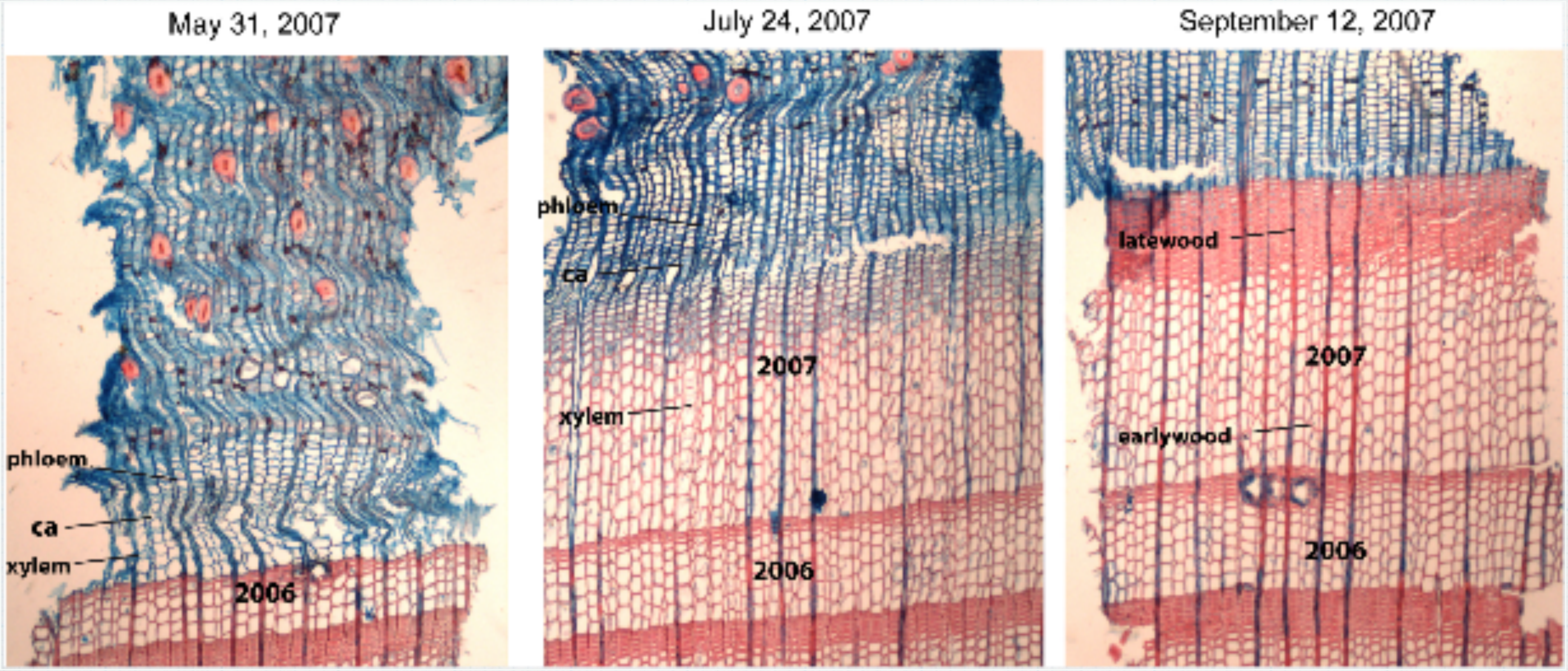


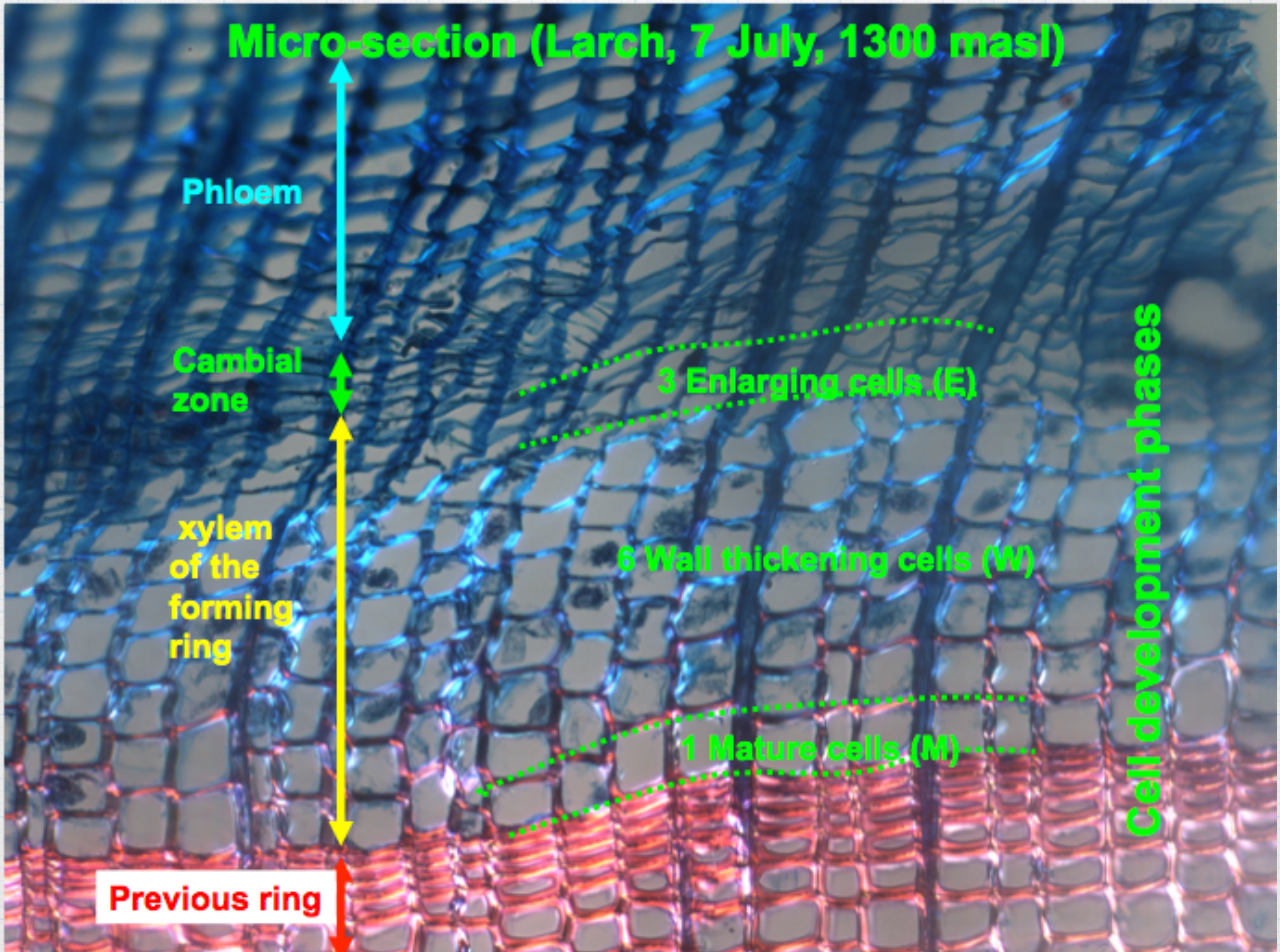
FIGURE 4 | Comparison of climate, growth rate, and modeled wood structure among the three ring types [narrow rings (green); wide rings (blue); IADF rings (red)]. **(A)** Daily temperature (dots) and precipitation (area) averaged for each the year in each ring type and smoothed with a LOESS function (span = 0.3, thick lines). The smoothed values have been used as input for the model. **(B)** Growth rates obtained by the model. **(C)** Derived tracheidogram for each ring type by using the quantified relation between average cell growth rates and tracheid diameter (**Figure 3D**). The number of cell is proportional to the modeled ring width. **(D)** Schema of the tracheidogram shown in **(C)**.

2. Xylogenesis

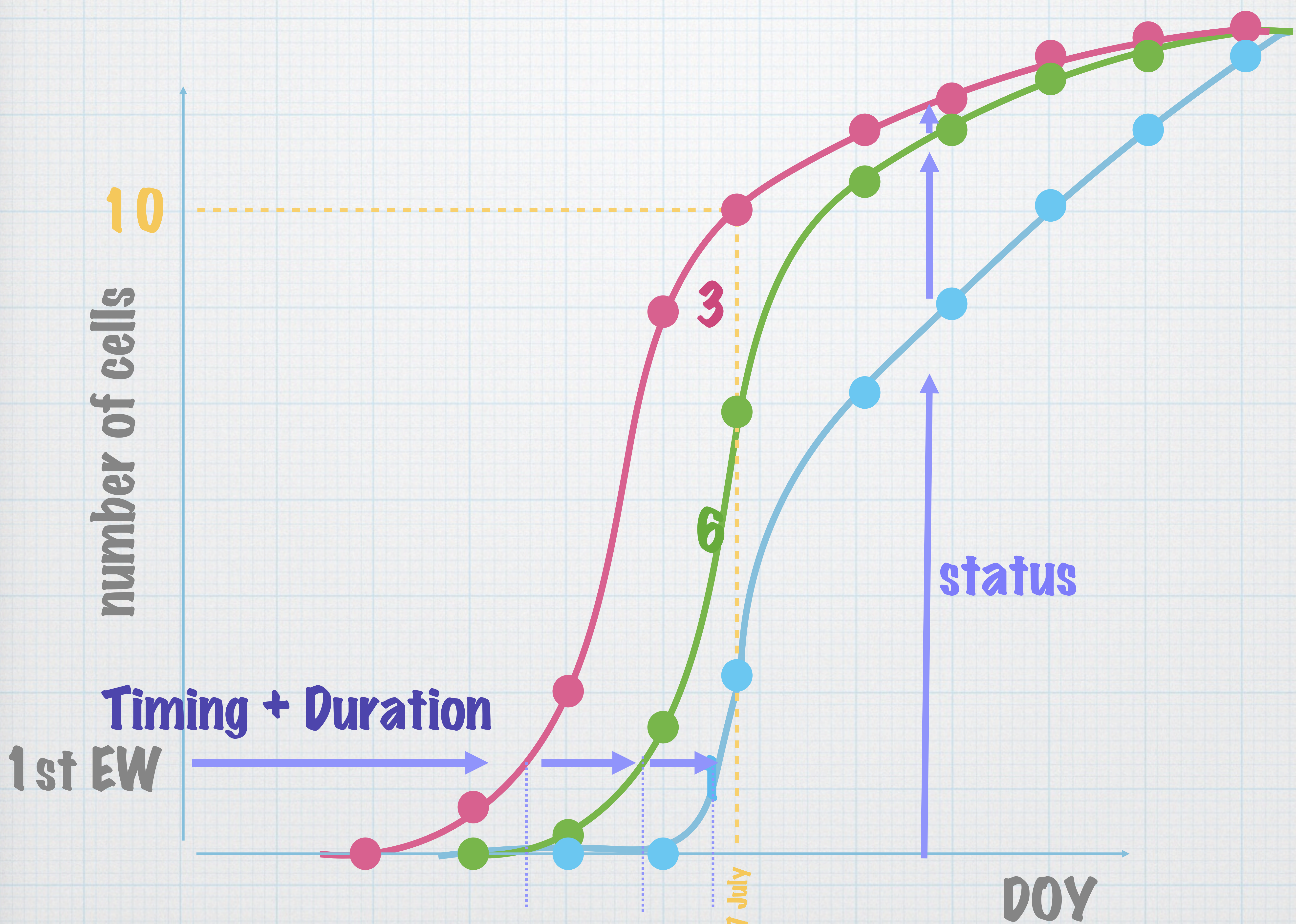


* to find out what is happening when and at what speed

Micro-coring

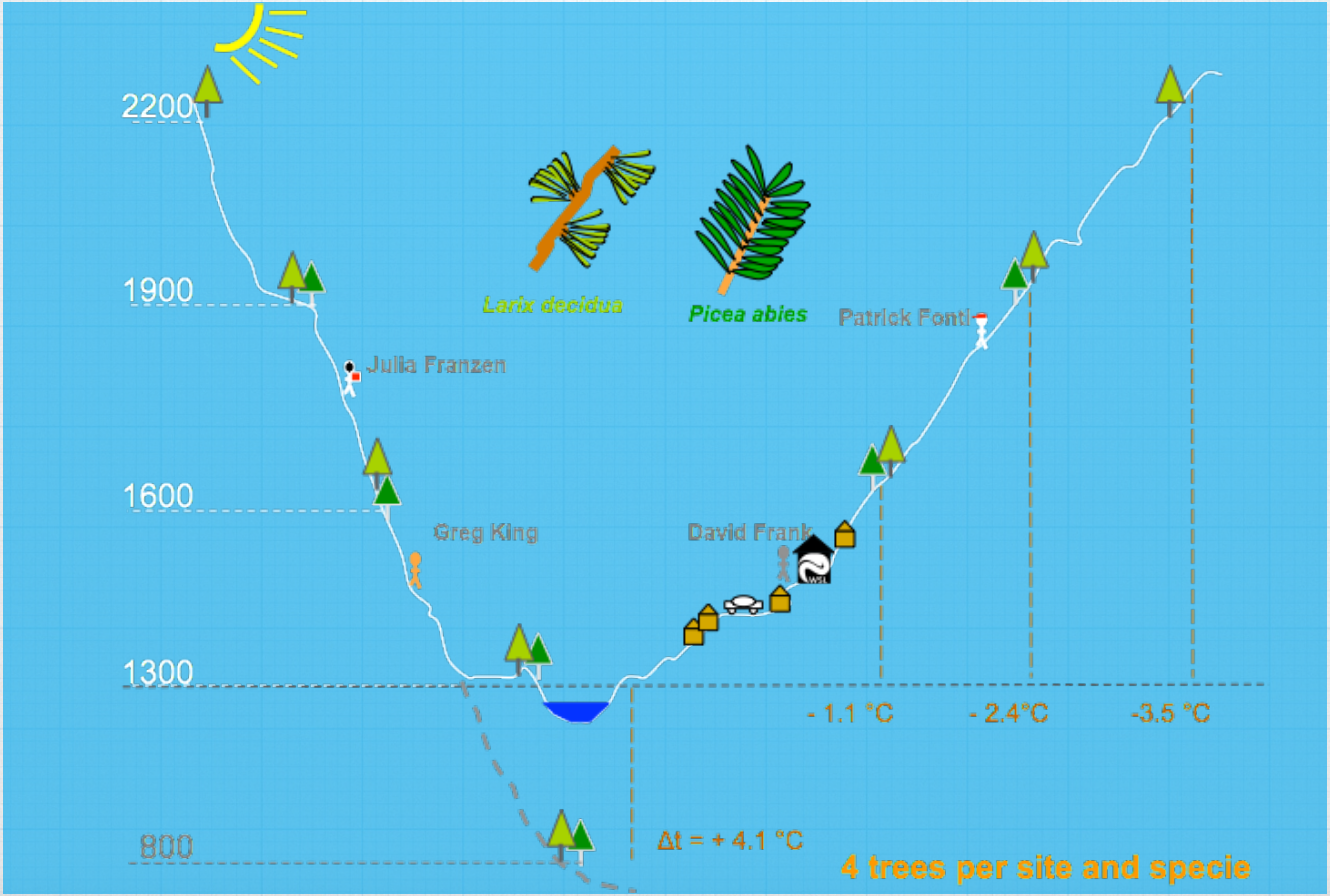


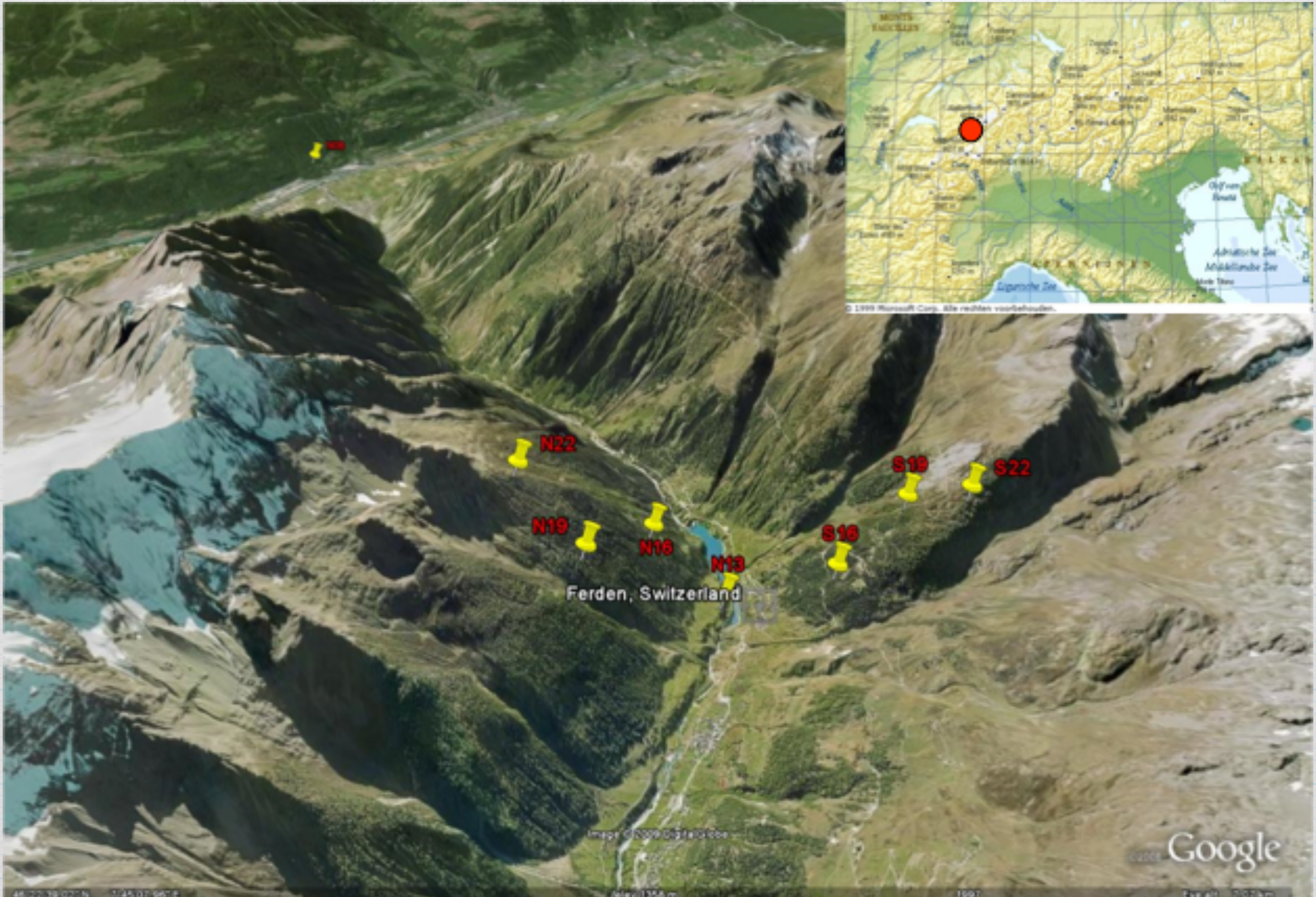
Micro-section (Larch, 7 July, 1300 masl)
Phloem
Cambial zone
xylem of the forming ring
Previous ring
3 Enlarging cells (E)
6 Wall thickening cells (W)
1 Mature cells (M)
Cell development phases



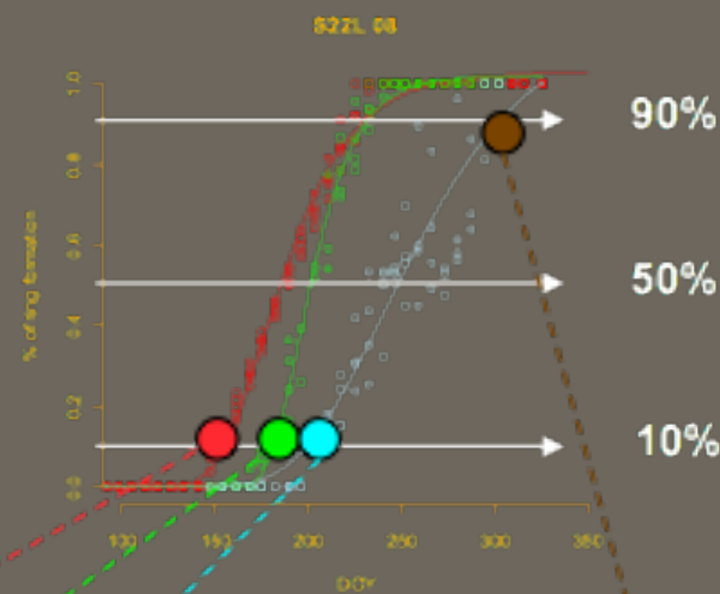
10
number of cells
3
6
status
Timing + Duration
1st EW
7 July
DOY

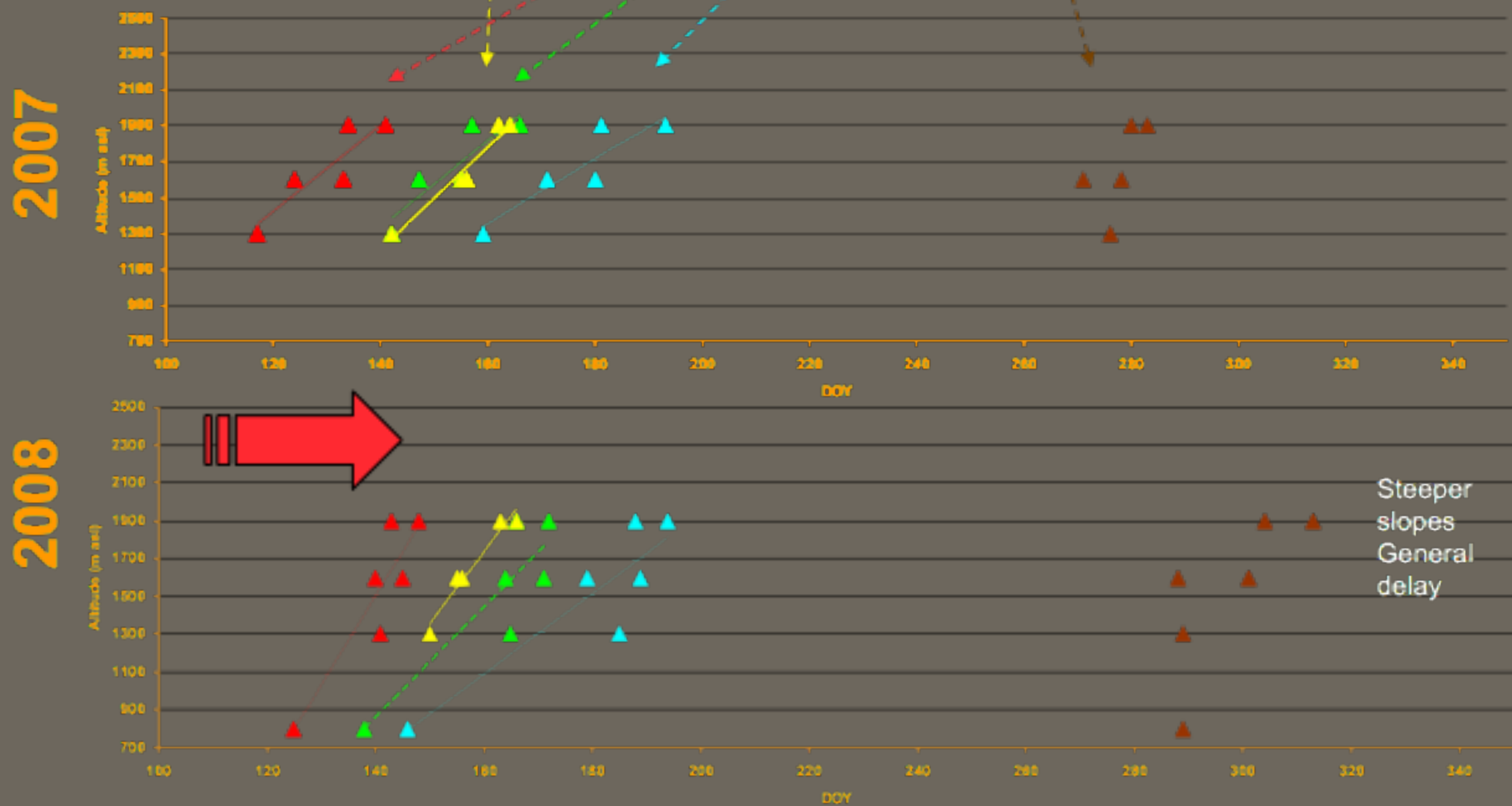
Example Ltal




N22
S19
S22
N19
N16
S16
N13
Ferden, Switzerland
Google

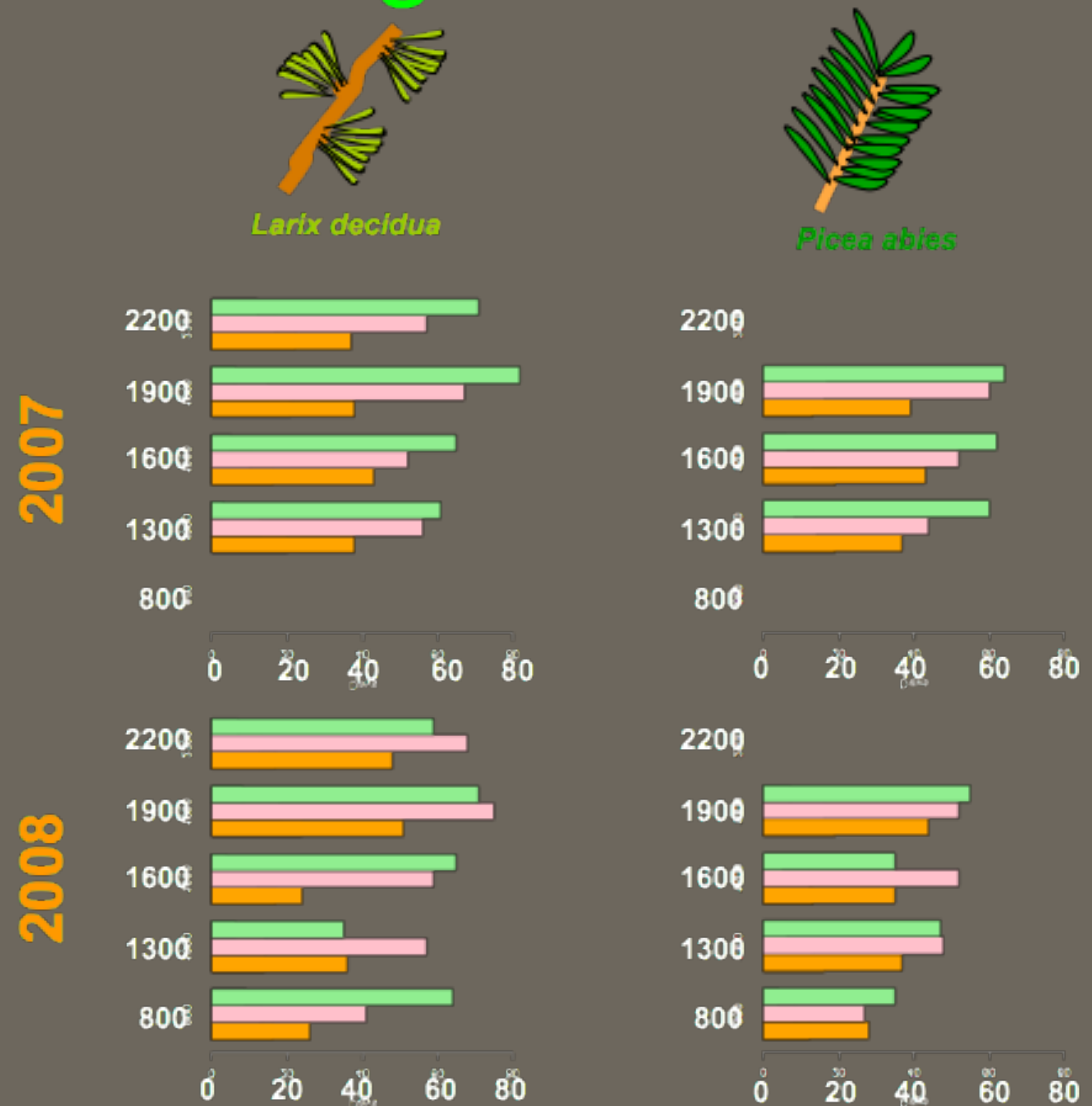
When





Steeper slopes
General delay

How long

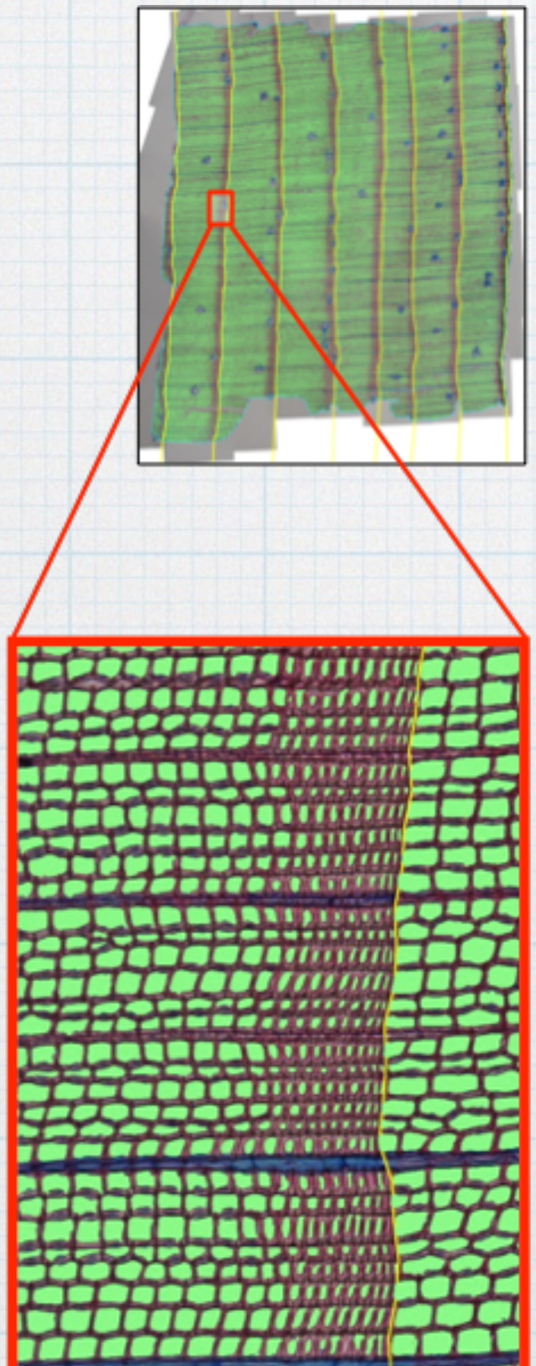


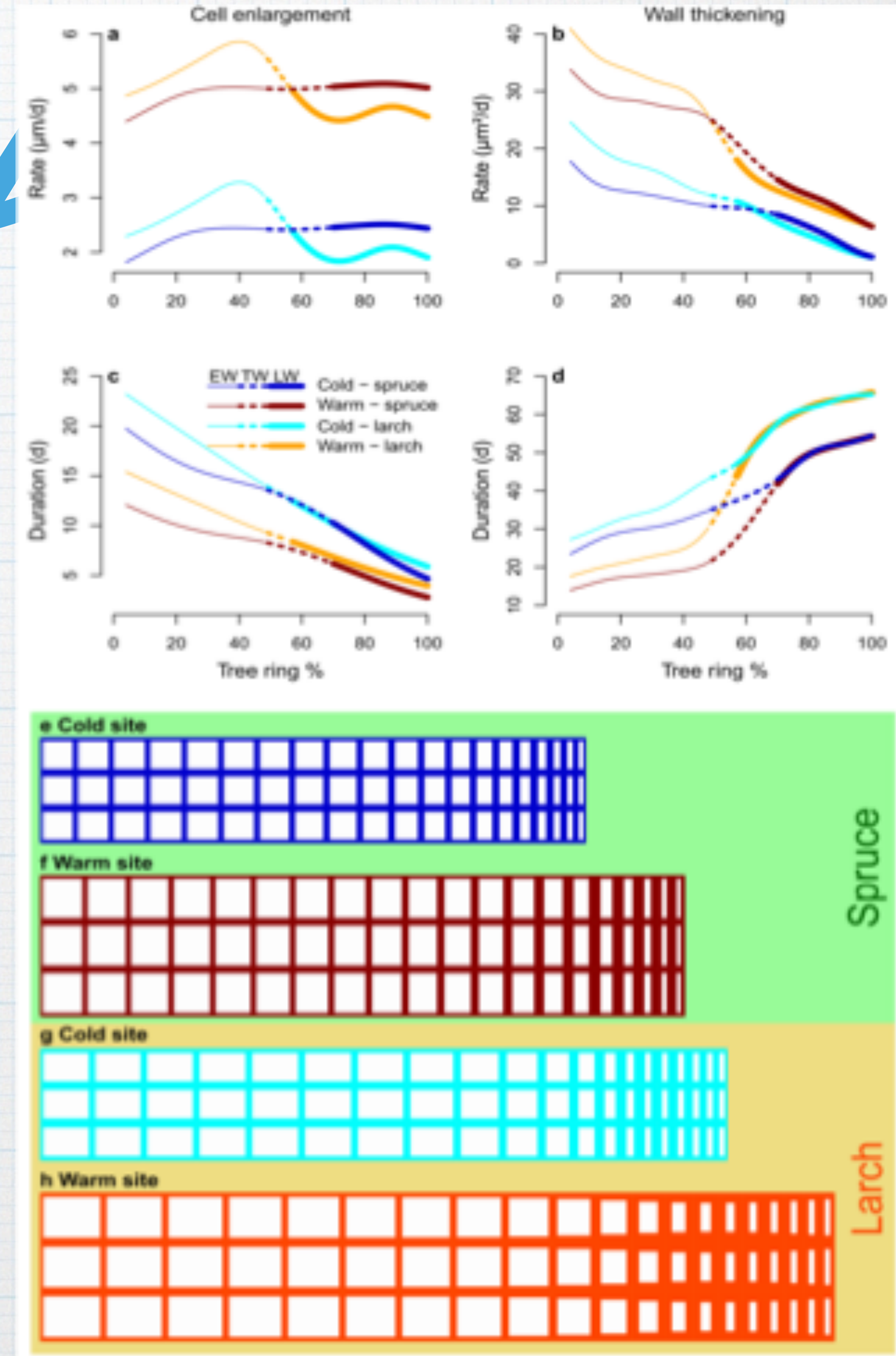
Roughly 40, 55, 65 days

Spruce faster

Increasing duration with elevation especially in 2008

Example
Cuny et al. 2014





Example
Cuny et al 2018

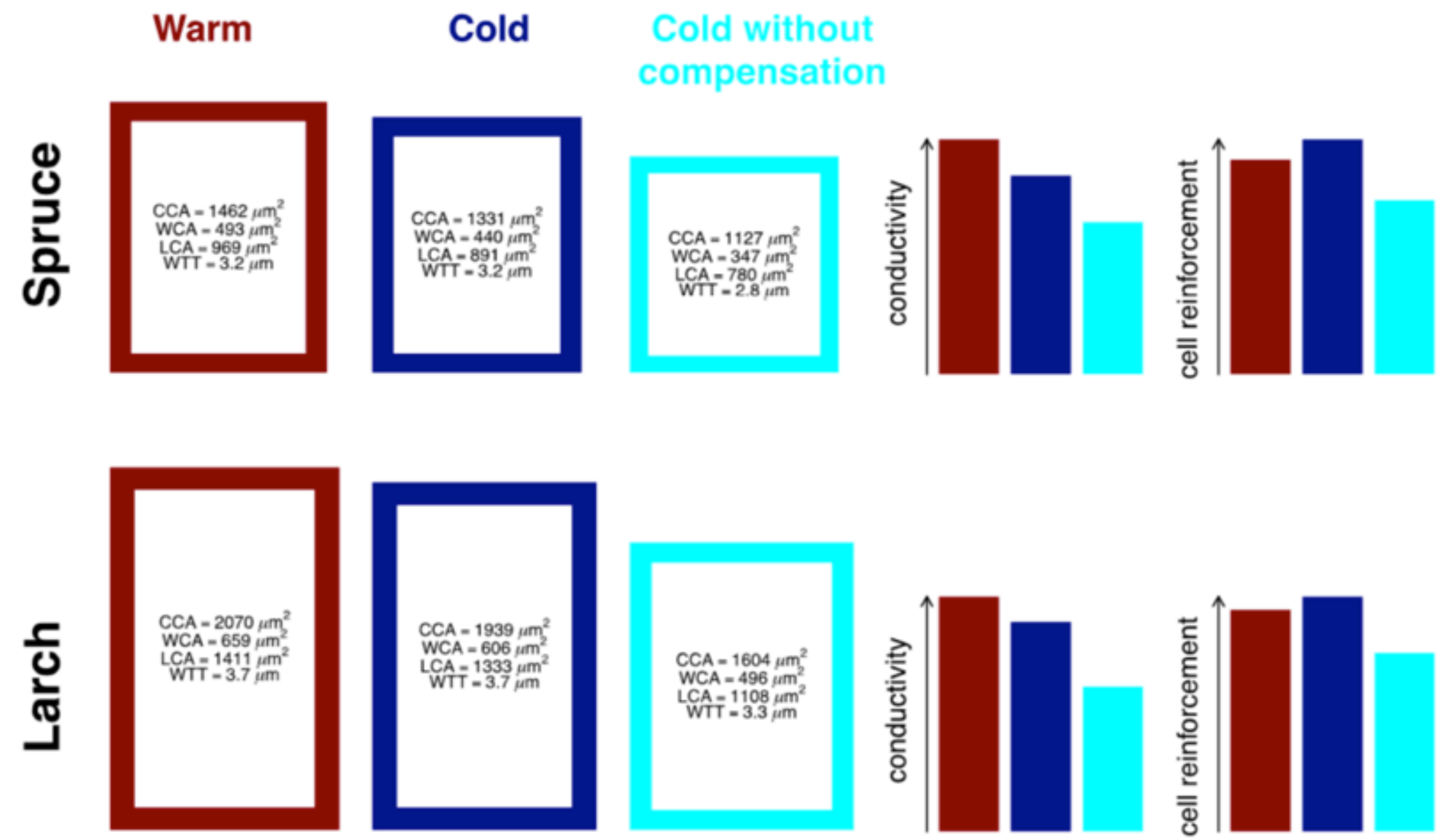
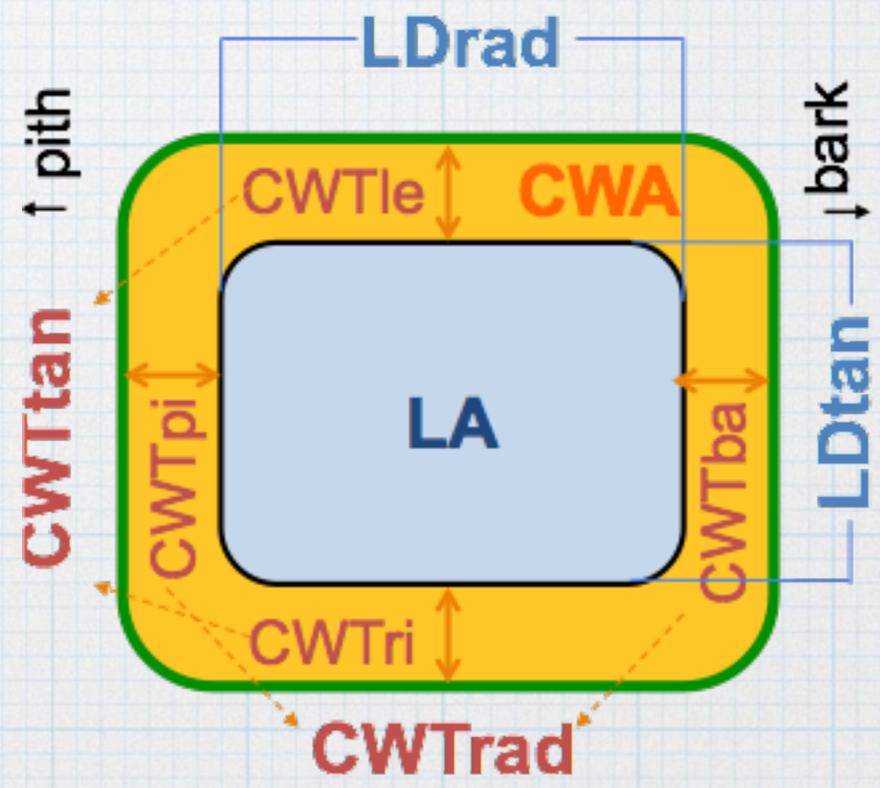


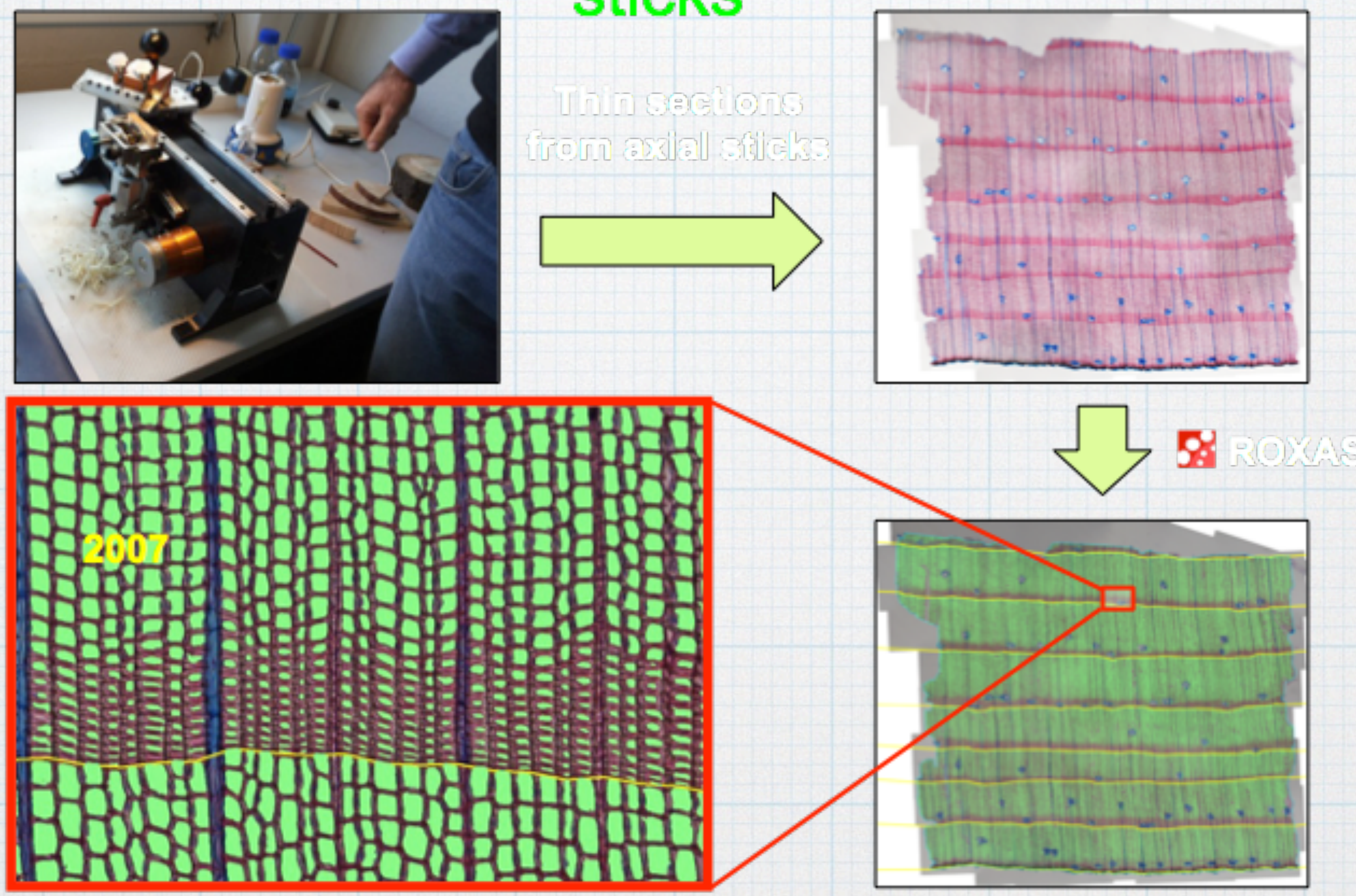
FIGURE 6 Morphology and associated derived cell functional performance of the earlywood xylem cells produced in European larch and Norway spruce simulated according to three scenarios (warm, cold, and cold without compensation). Simulated tracheids were built using the relationships presented in Figure 3 and assuming a 5°C thermal gradient between the "warm" and "cold" scenarios. The "cold without compensation" scenario corresponds to the simulations performed for the theoretical cold site but using the durations of the theoretical warm site in order to test the effect of the compensation played by the duration on the final cell dimensions and mean associated functions (from the bootstrapped models). The cell, wall and lumen cross-sectional areas (CCA, WCA, and LCA), and the tangential wall thickness (WTT) of the simulated tracheids are given [Colour figure can be viewed at wileyonlinelibrary.com]

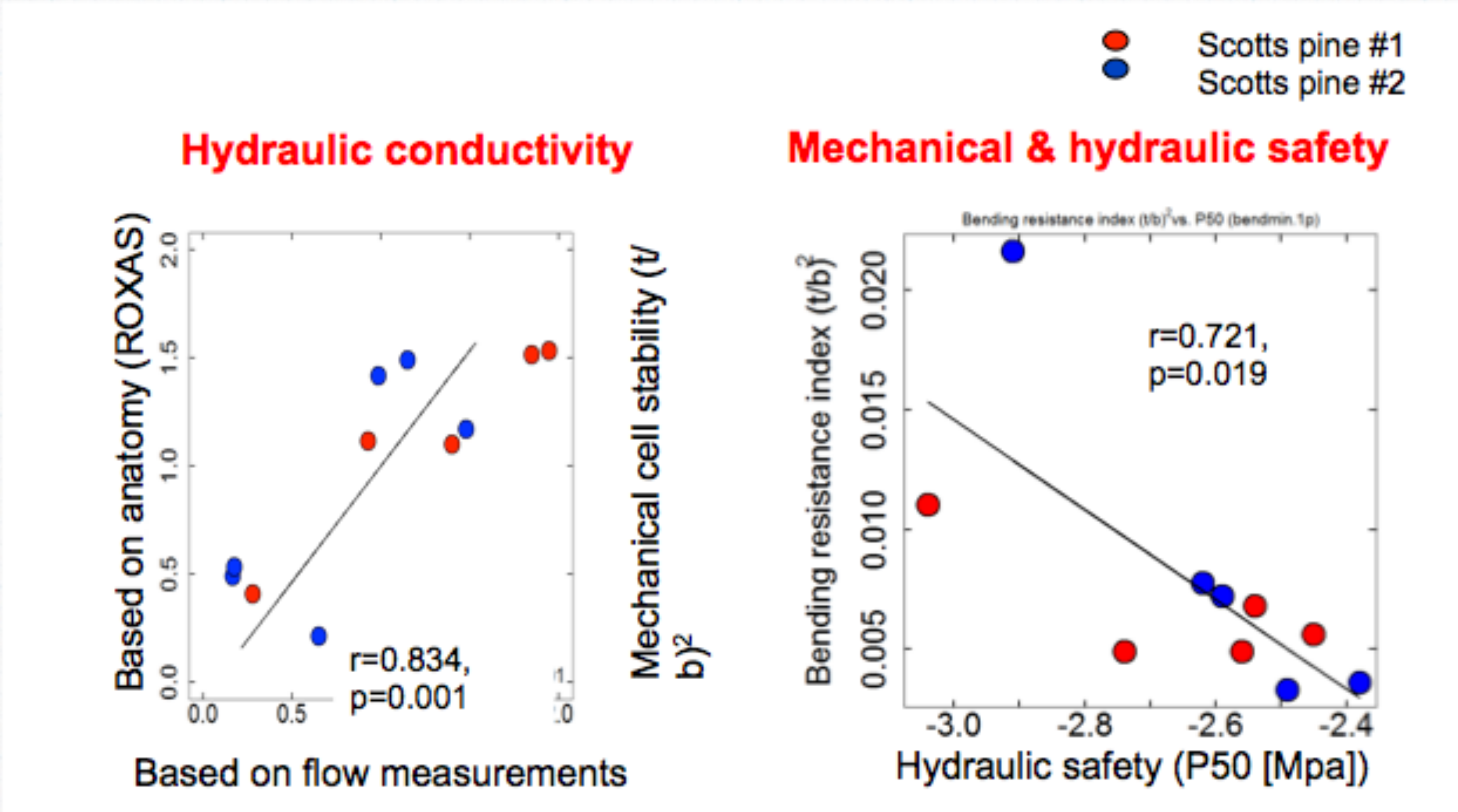
Impact on functions

- cold or dry => less, smaller and thicker cells
- increased density?
- reduced hydraulic
- increased mortality?



Quantifying lumina of all tracheids in axial sticks

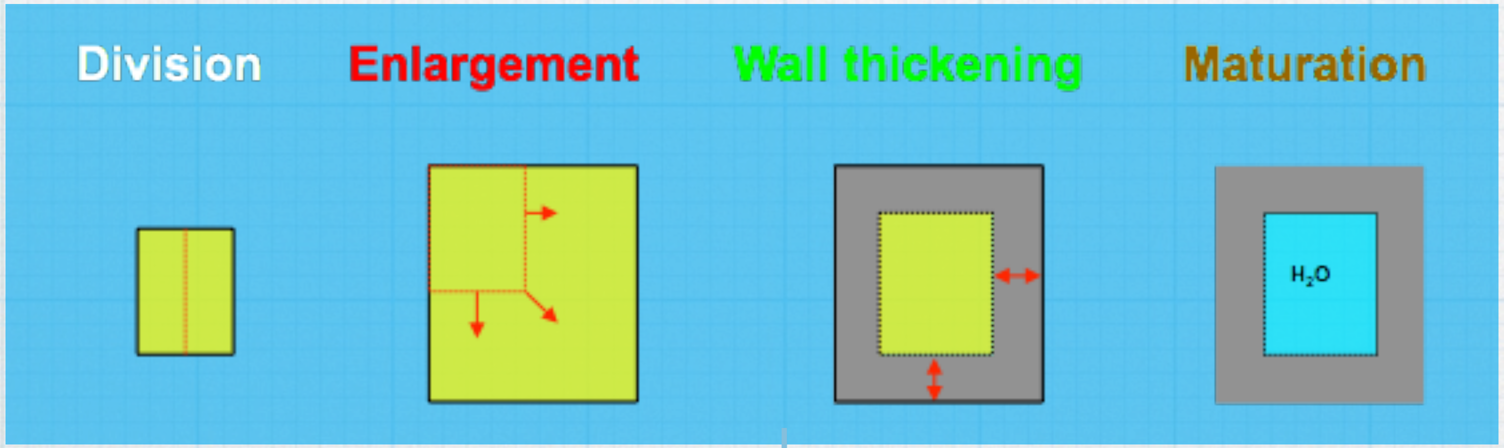




Anatomy and hydraulics match closely.
Anatomy may therefore provide a long-term perspective on tree functioning!

The fundamentals

Climate change
weather



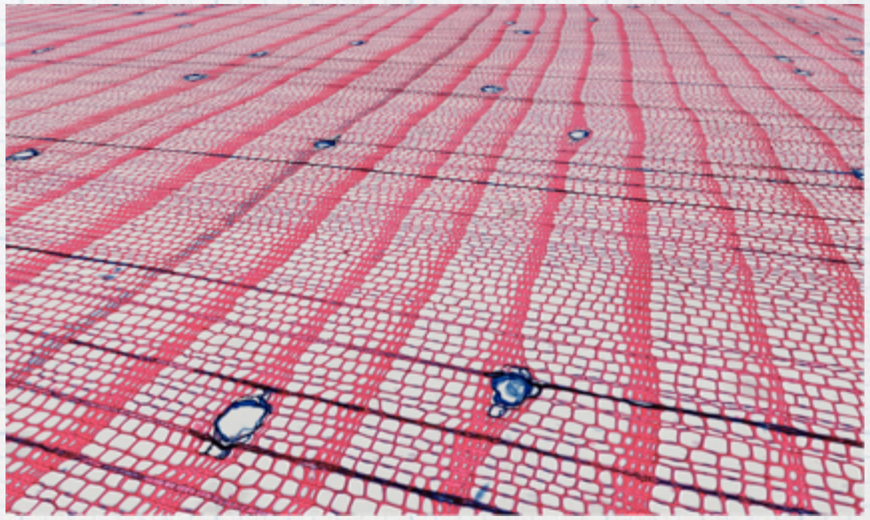
wood structure

functioning
performance/survival

wood properties

Conclusions

* Climate change affects structure and function, however the unknown is about
  * how
  * how much
  * what are the consequences



* two methods: tree-ring anatomy and xylogenesis

* First indications:
  * in cold environment heat promotes larger and thicker cells
  * in dry environment too much heat and drought induce less, smaller and denser cells

* Still more to investigate
  * hardwood
  * structure-function-properties