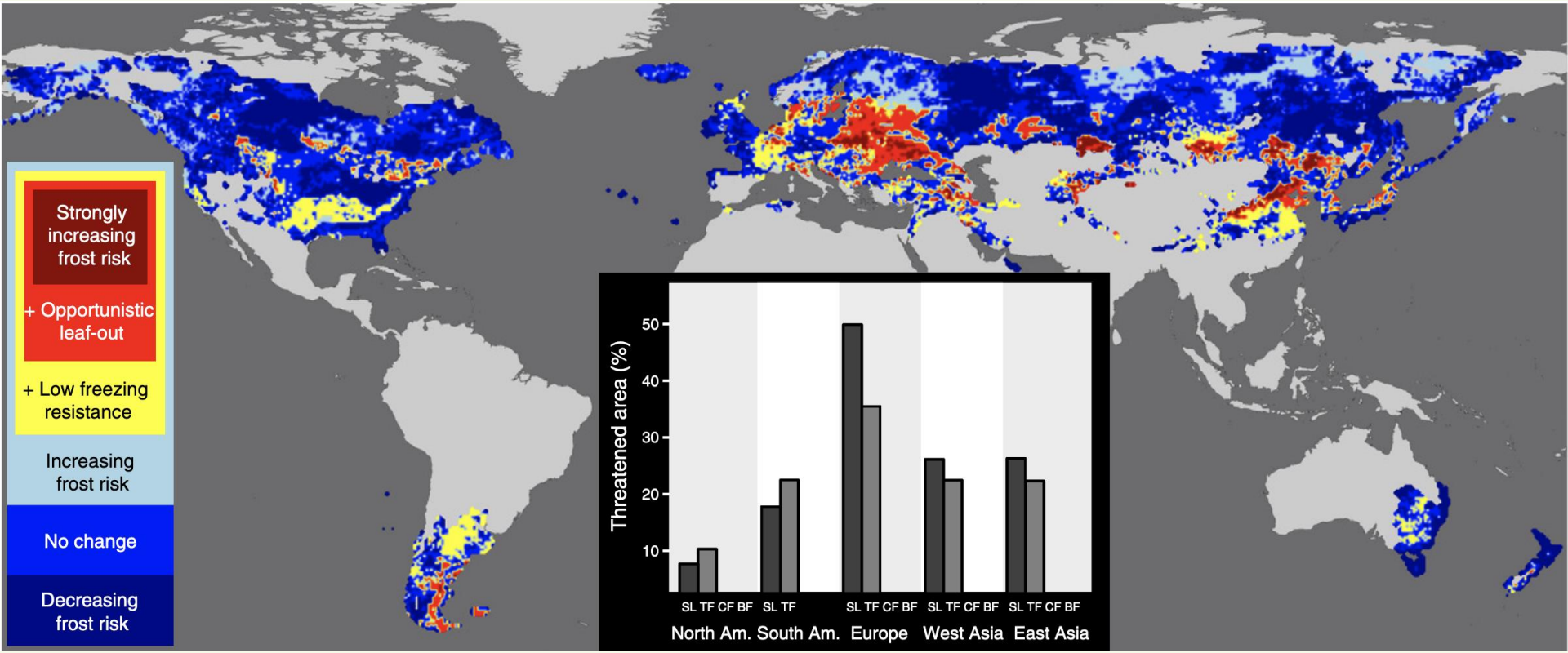
No risk – no fun:
The penalty of spring frost damages on deciduous temperate trees

Frederik Baumgarten, Arthur Gessler & Yann Vitasse

WSL

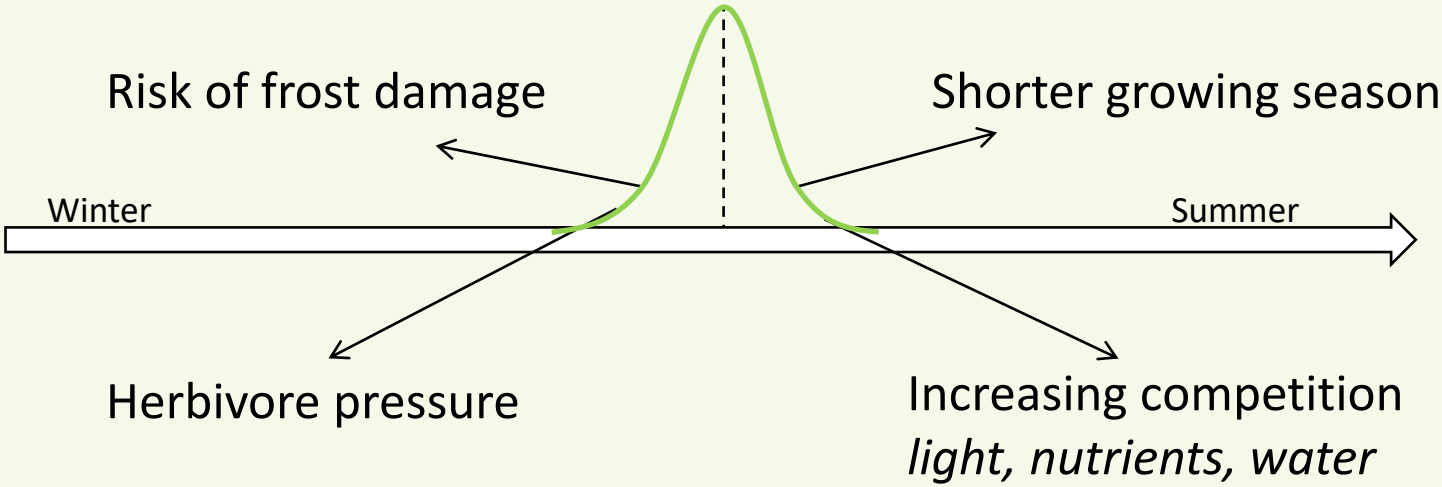
10. May 2020, Jura mountains, Weissenstein, 1'385 m a.s.l

RISK OF SPRING FROST DAMAGES

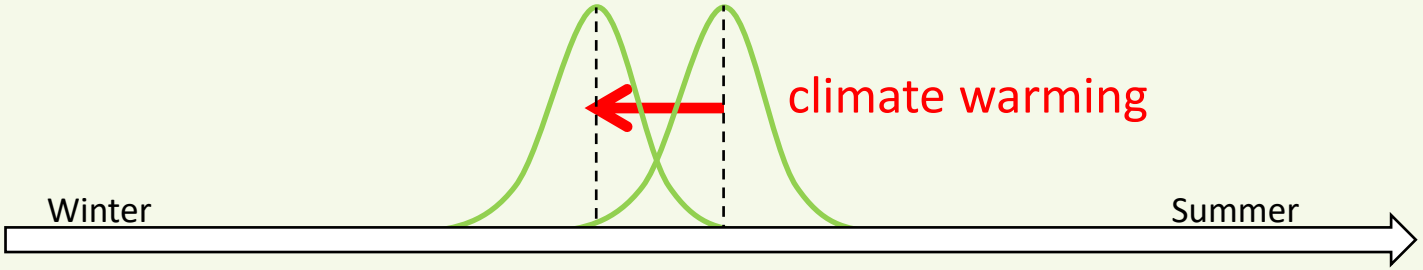


Zohner et al .2020; PNAS

Optimal time to leaf-out



Optimal time to leaf-out

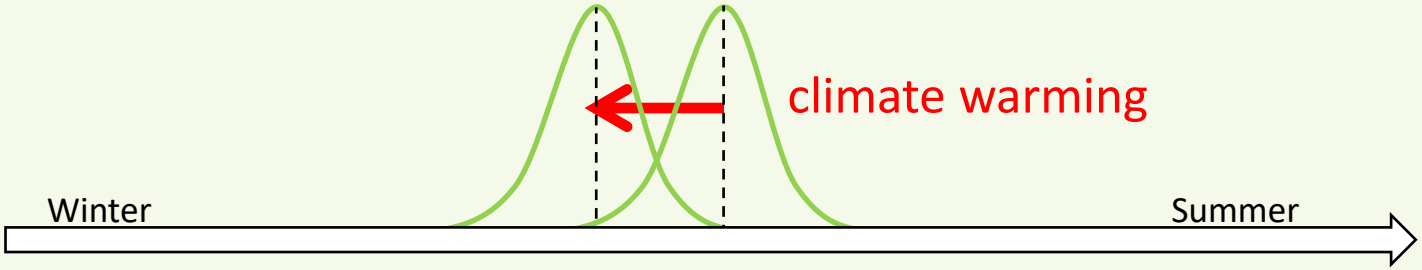


2 Scenarios:

Gains due to extended GS

Penalty of frost damage

Optimal time to leaf-out



2 Scenarios:

Gains due to extended GS

Penalty of frost damage

Life history / Plant traits

Age
juvenile vs. adult

Leaf N-content (investment)

freezing resistance

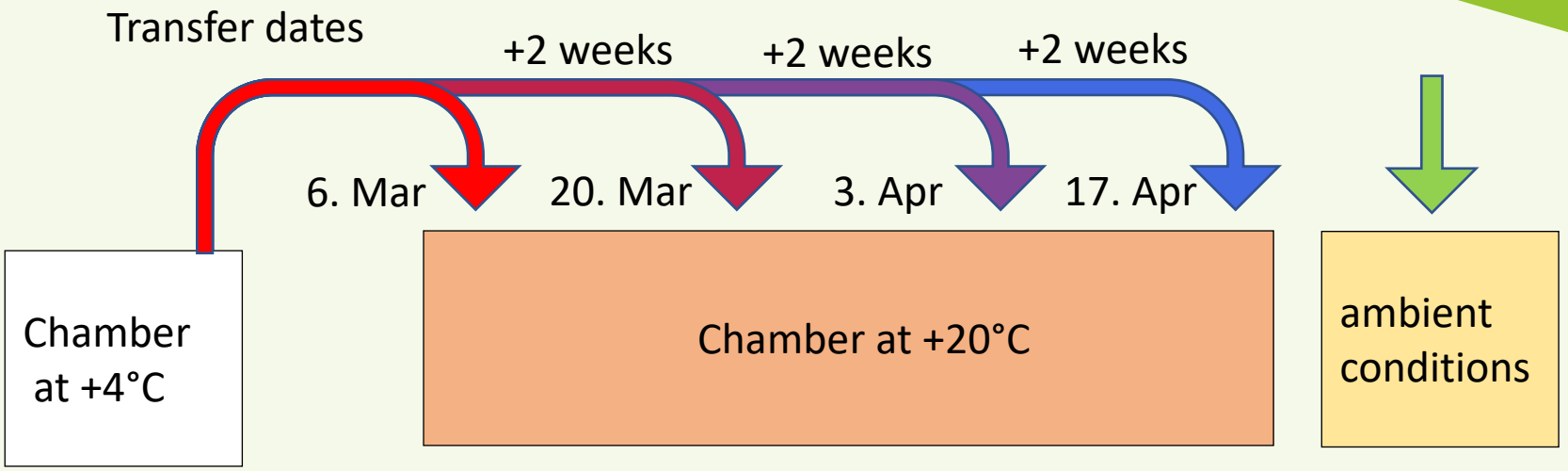
Recovery potential

Research Questions

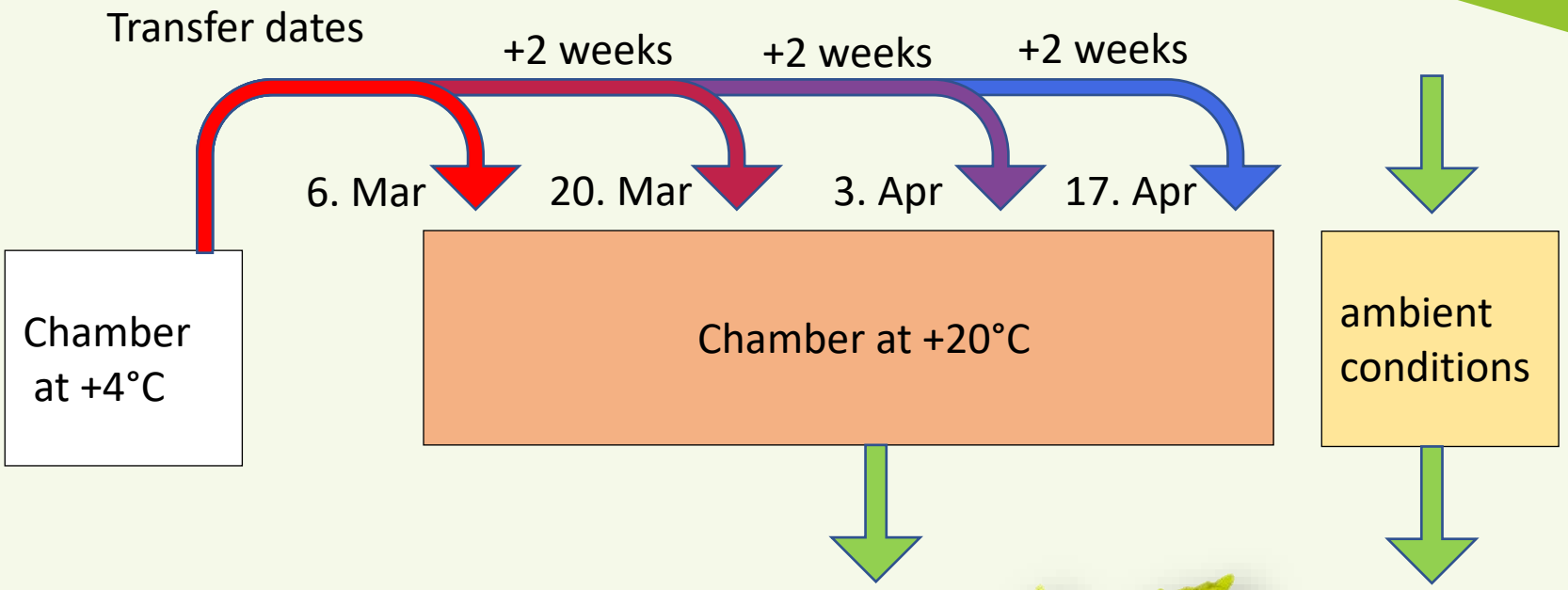
- How well can trees recover from a damaging frost?
- Does leaf-out timing influence growth/recovery performance?

Canopy regreening, N-content, growth increment, NSC

Experimental Design

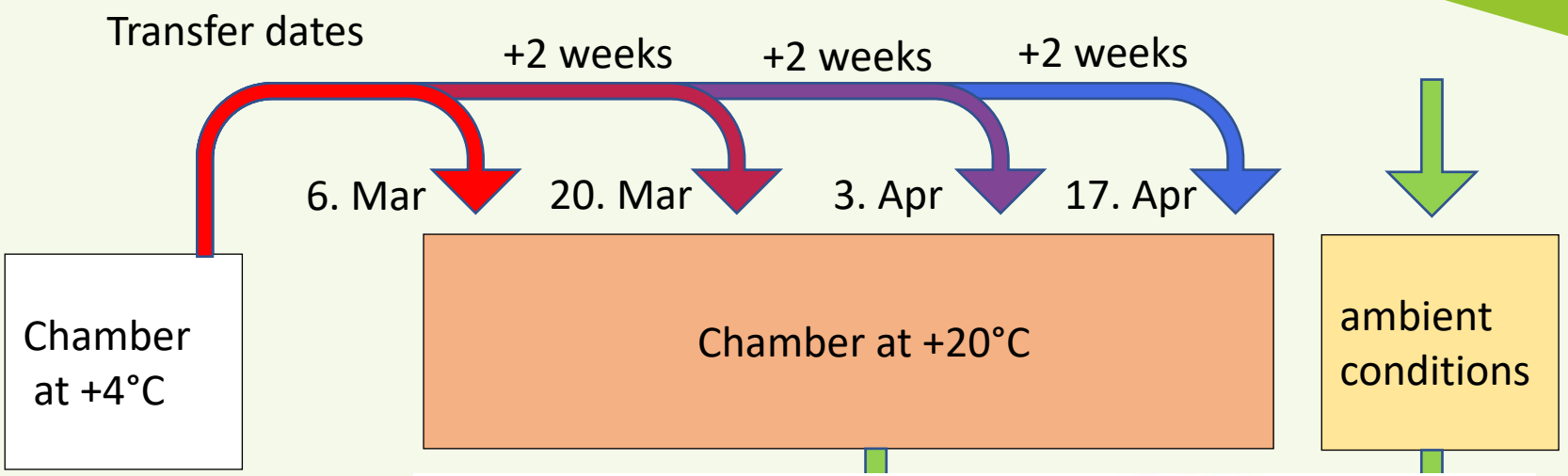


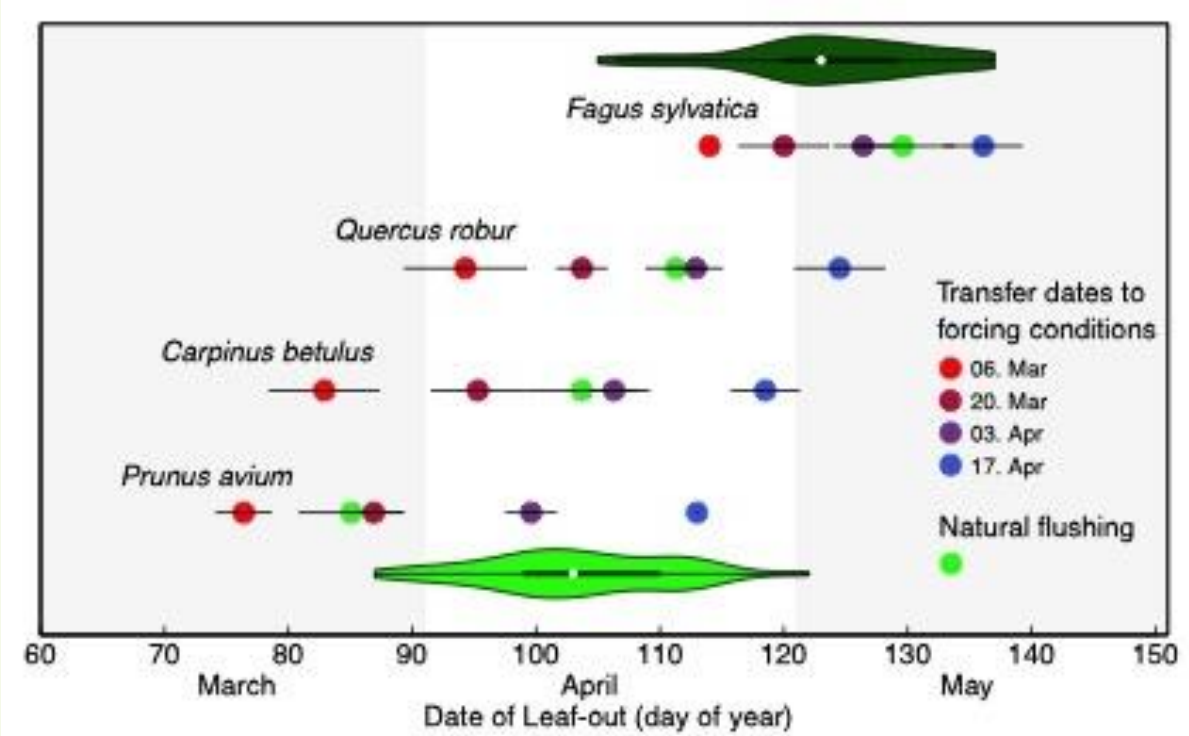
Experimental Design



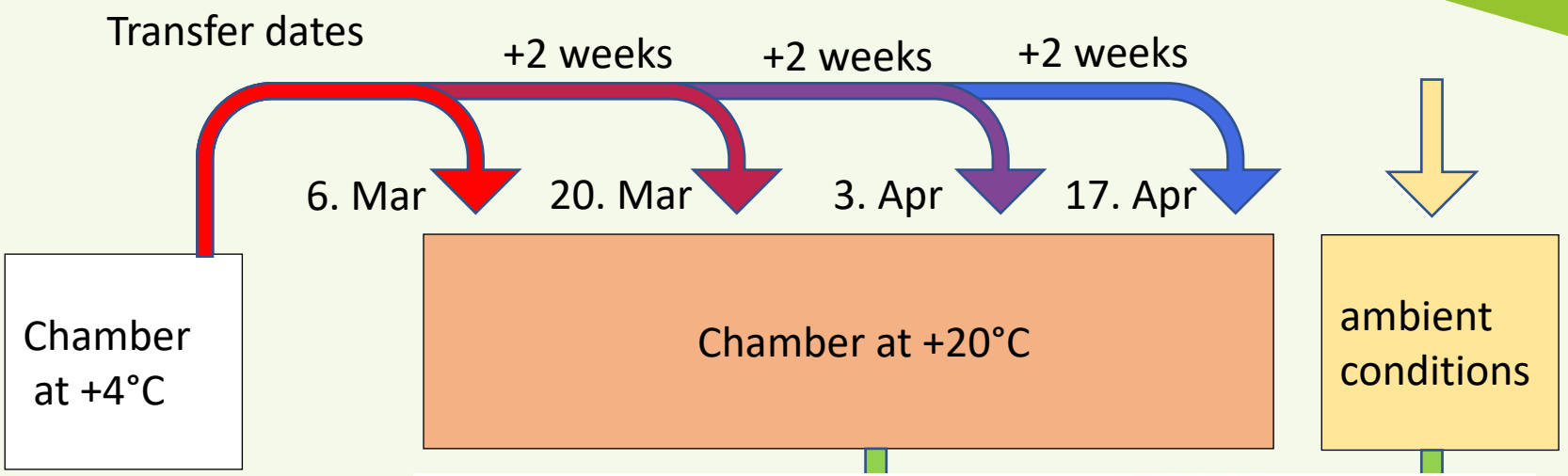
leaf-out

Experimental Design



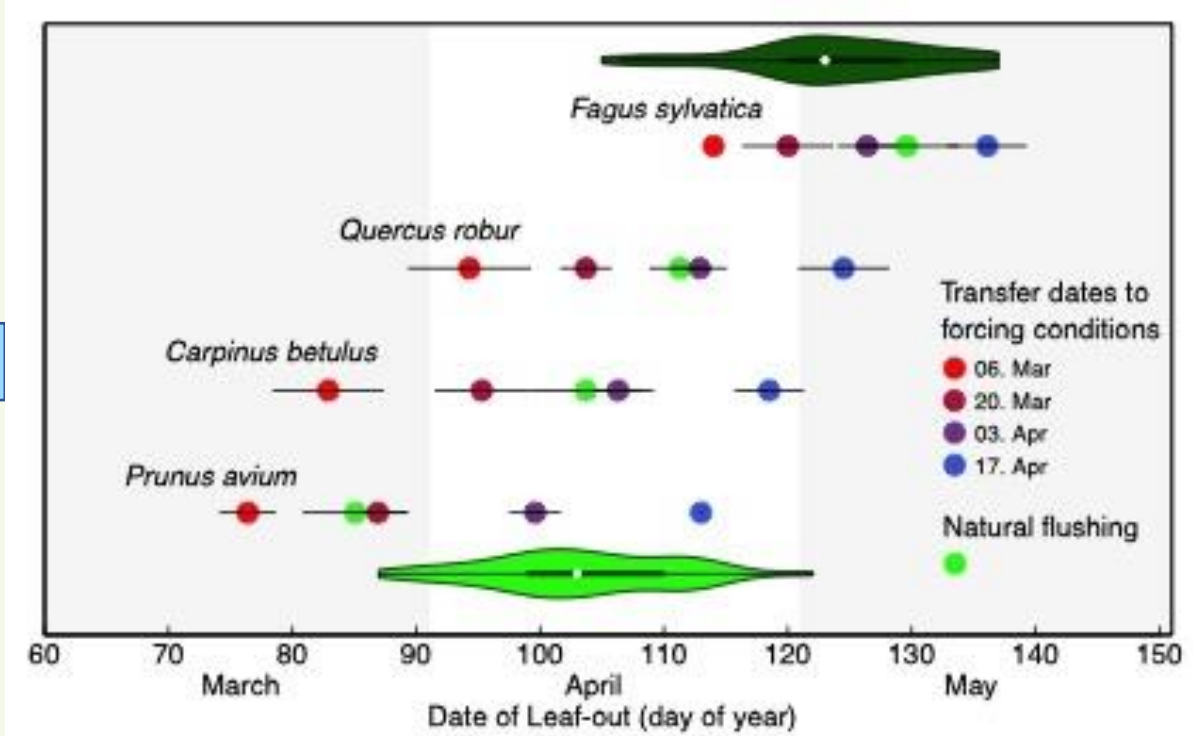


Experimental Design



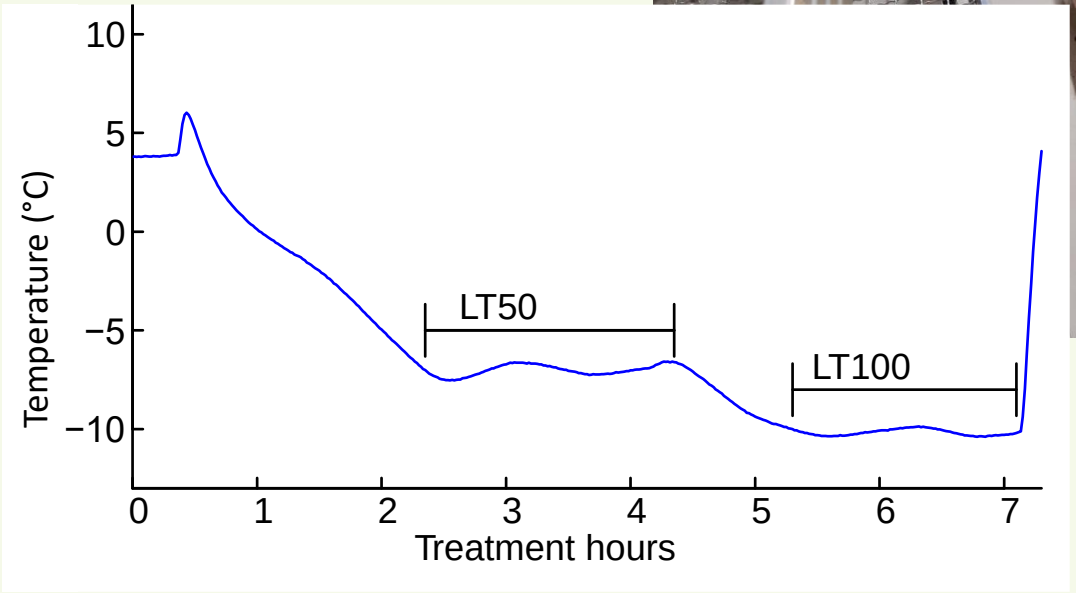
Artificial Frost

Control



Freezing treatments

Freezing treatments



Freezing curve for *Prunus avium*

Freezing Damages

Prunus avium control

LT_{100} freezing damage

Recovery at ambient conditions

WSL, Research facility near Zurich

Mortality & Canopy recovery

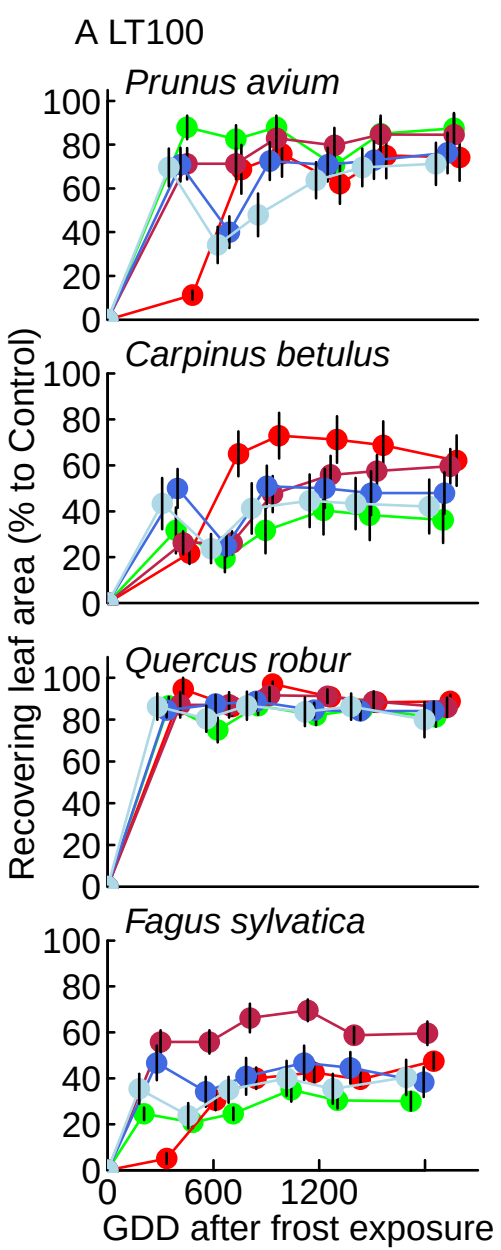
Mortality (%)

	Frost treatment	
species	**control**	**LT_{100}**
Prunus	0	8
Carpinus	0	32
Quercus	0	2
Fagus	0	8

Mortality & Canopy recovery

Mortality (%)

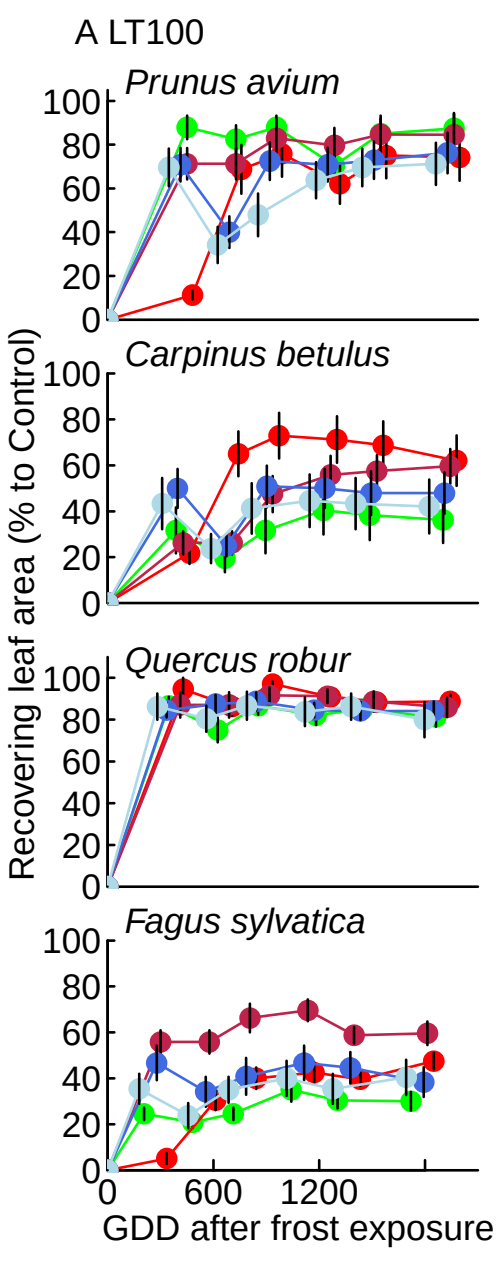
	Frost treatment	
species	**control**	**LT_{100}**
Prunus	0	8
Carpinus	0	32
Quercus	0	2
Fagus	0	8

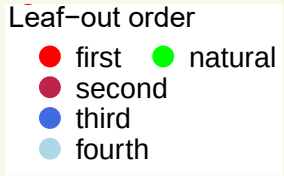


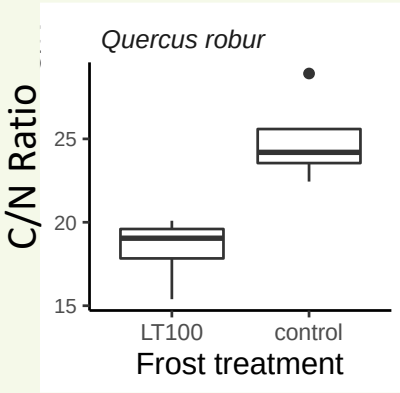
Mortality & Canopy recovery

Mortality (%)

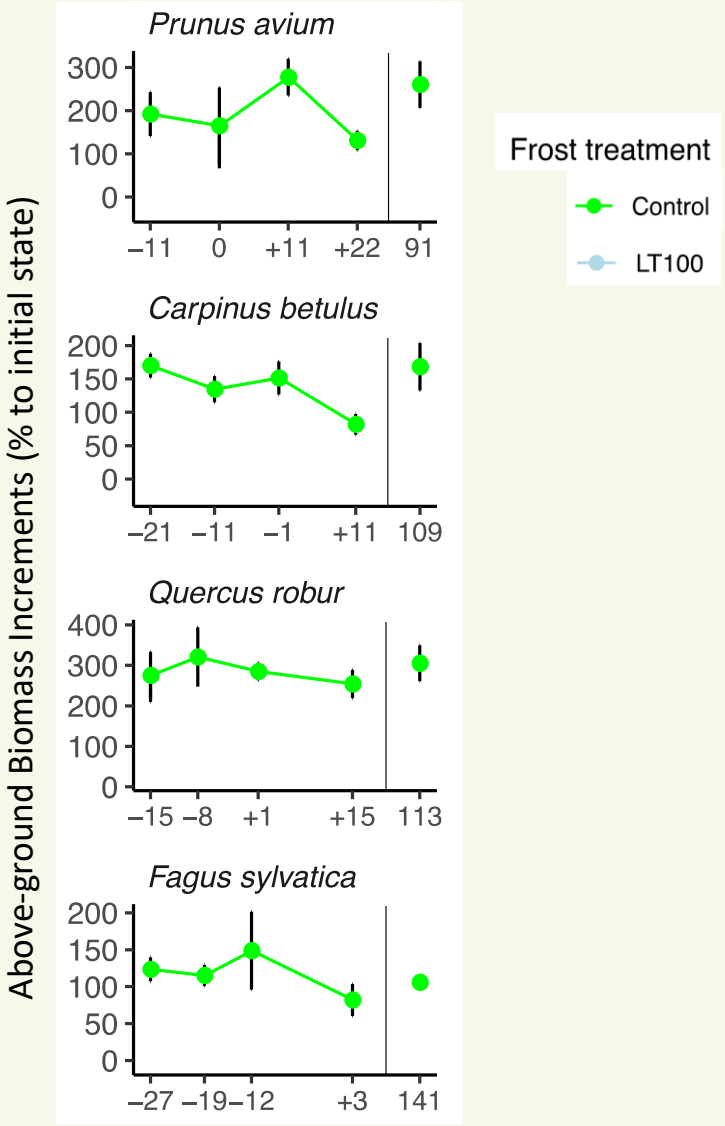
	Frost treatment	
species	**control**	**LT_{100}**
Prunus	0	8
Carpinus	0	32
Quercus	0	2
Fagus	0	8





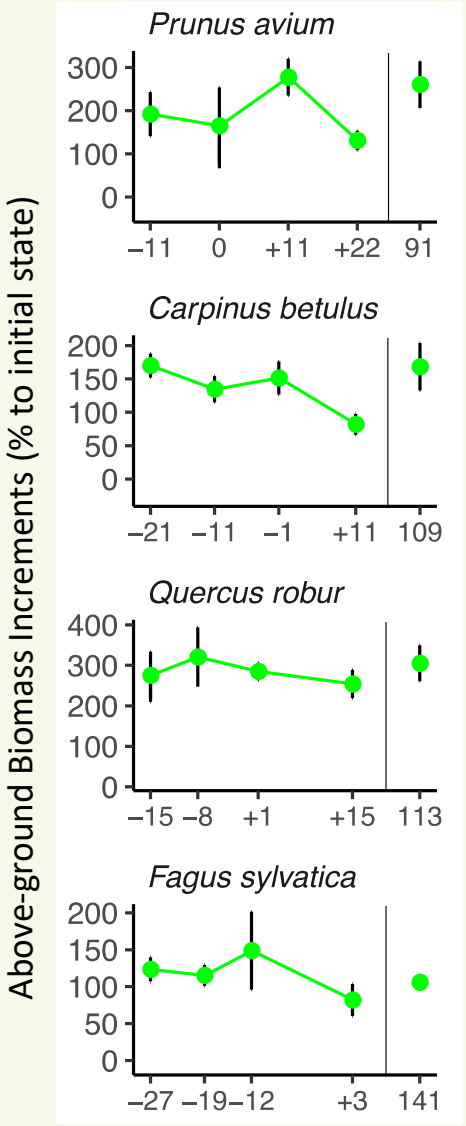


Growth Performance/Recovery



Induced shifts in leaf-out (days)
relative to the natural event (doy)

Growth Performance/Recovery

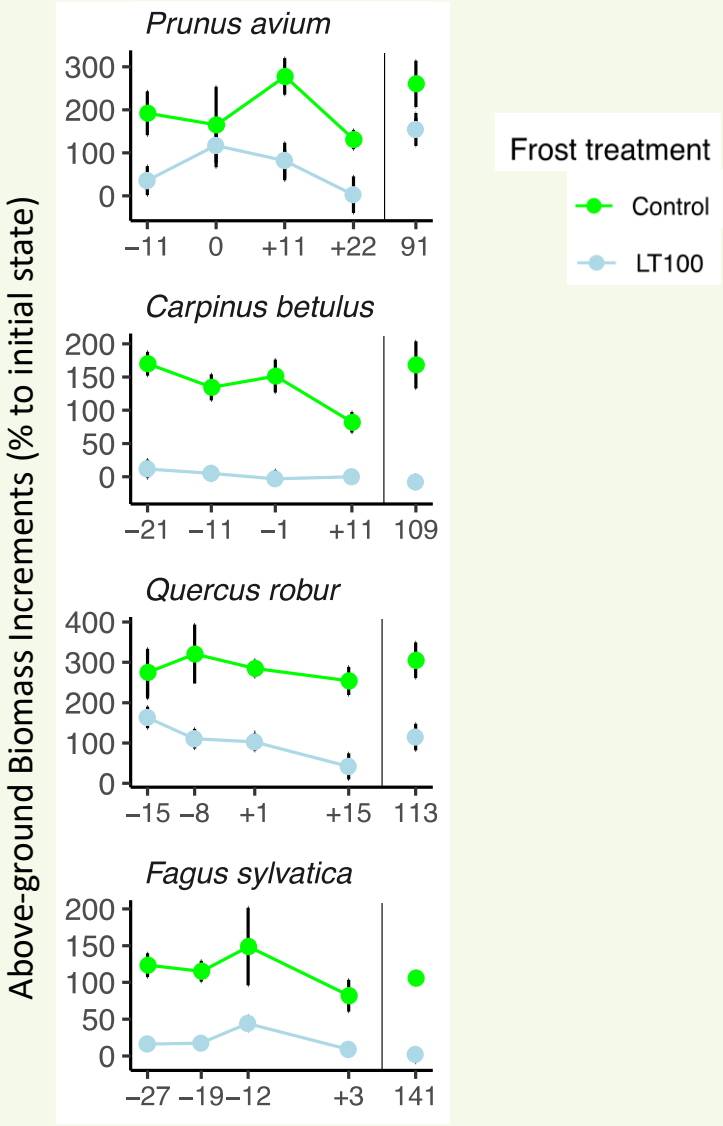


Induced shifts in leaf-out (days) relative to the natural event (doy)

Black cherry aphid

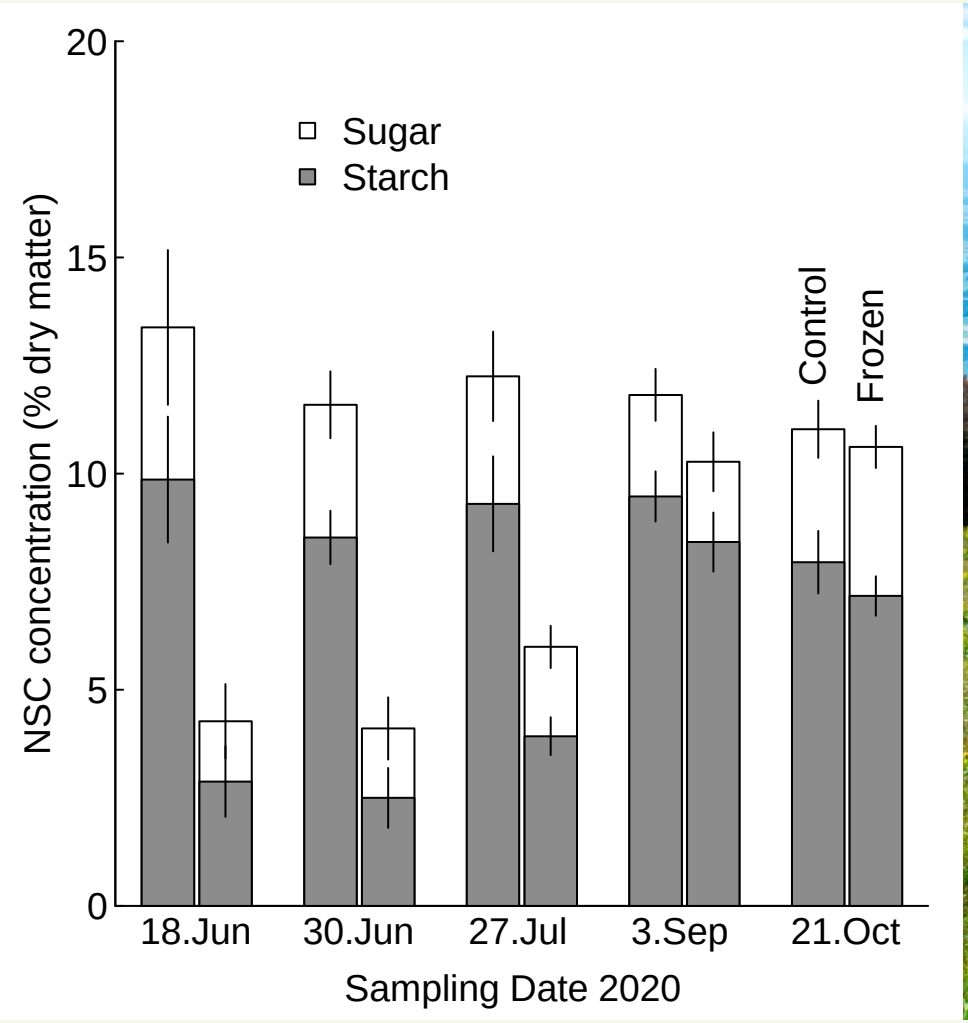
Wooly beech aphid

Growth Performance/Recovery



Induced shifts in leaf-out (days) relative to the natural event (doy)

Full NSC recovery



Conclusion

Quercus robur

Prunus avium

Fagus sylvatica

Carpinus betulus

Recovery potential

deployment of reserve buds

ability to resprout from the stem base

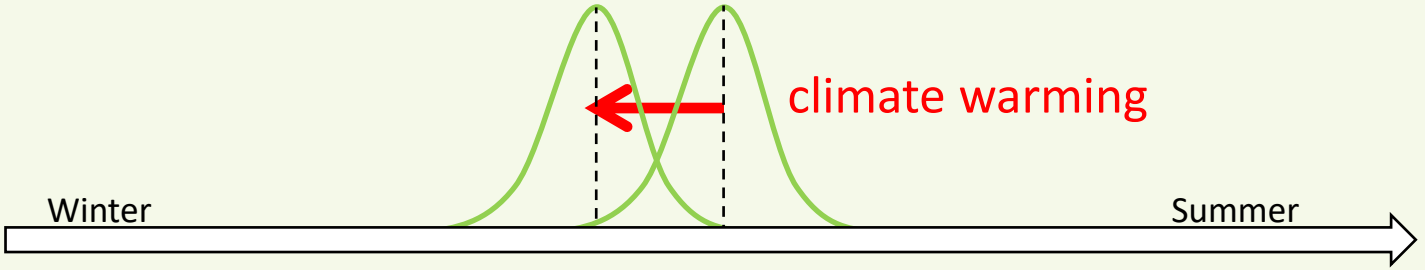
delayed senescence

High mortality

Common responses

- Presumably higher A_{max} of emerging leaves after frost
- Full NSC recovery at the expense of growth

Conclusion



2 Scenarios:

Gains due to extended GS

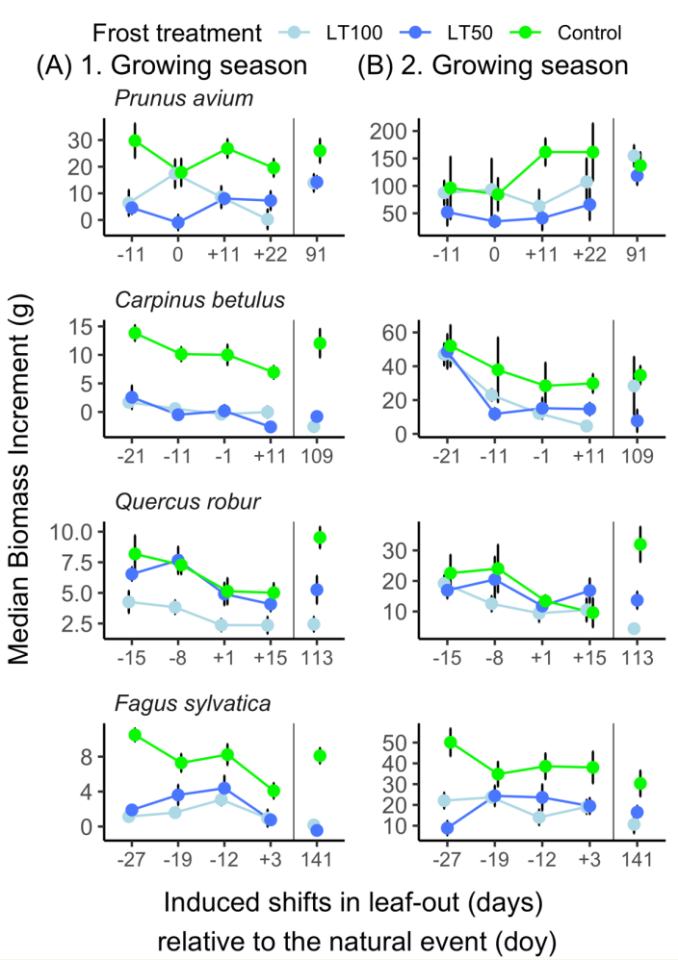
Penalty of frost damage

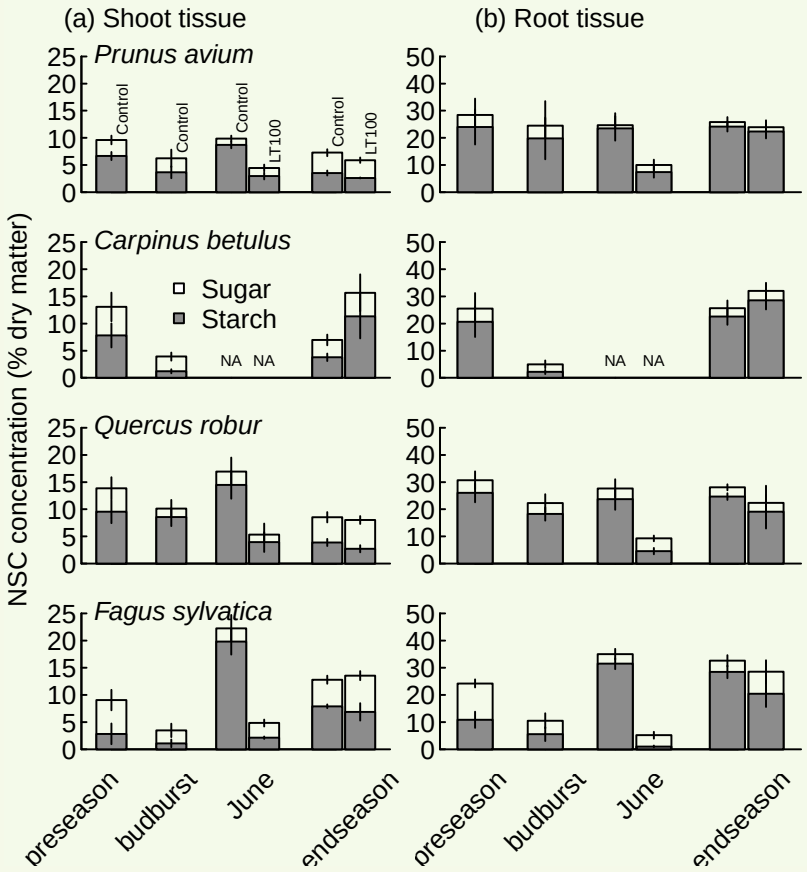
Some benefits with moderately advancing budburst

Considerable losses in all species, partly with mortality

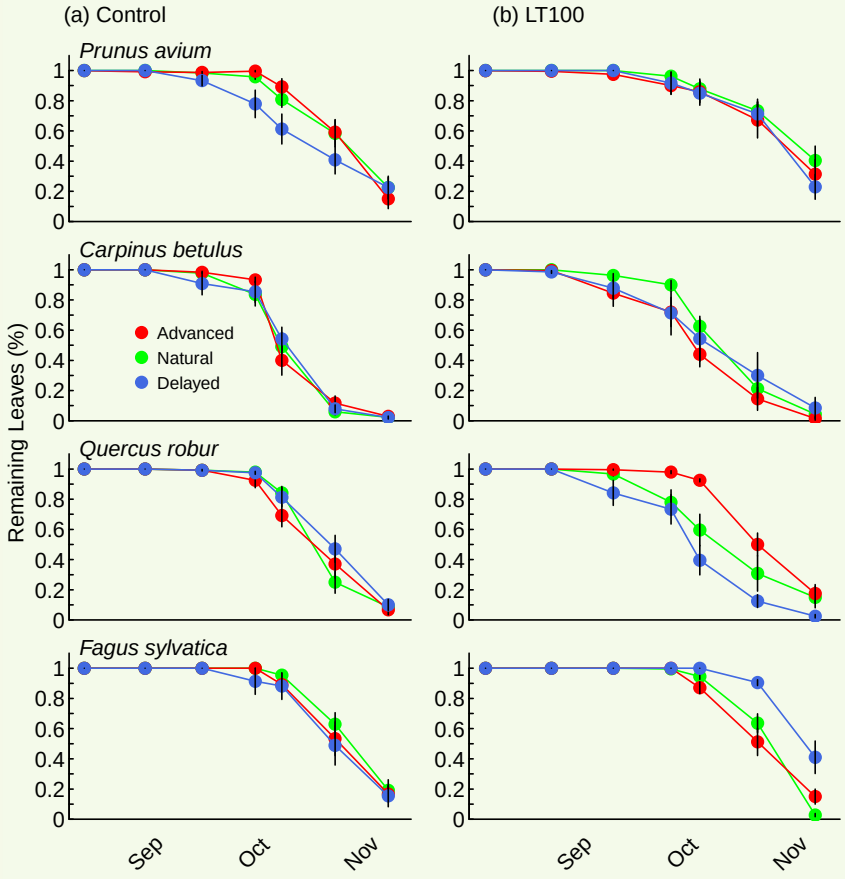
- Delayed leaf-out diminishes recovery after a damaging frost event

Frederik.Baumgarten@wsl.ch


Frost treatment
LT100
LT50
Control
(A) 1. Growing season
(B) 2. Growing season
Prunus avium
Carpinus betulus
Quercus robur
Fagus sylvatica
Median Biomass Increment (g)
Induced shifts in leaf-out (days)
relative to the natural event (doy)



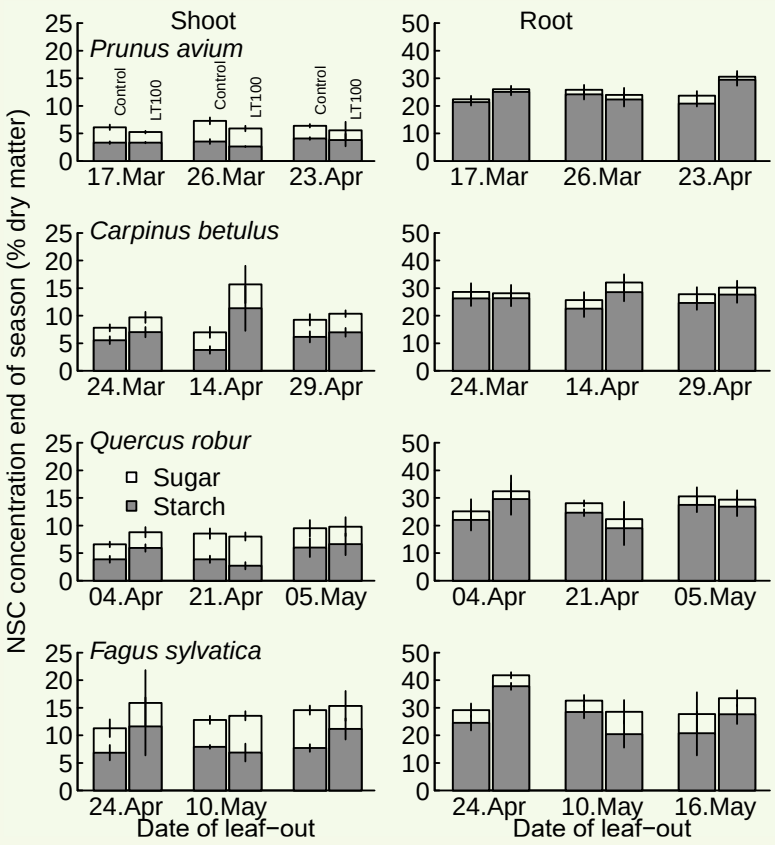
Frost treatment substantially reduced starch levels in June, when control levels were already high

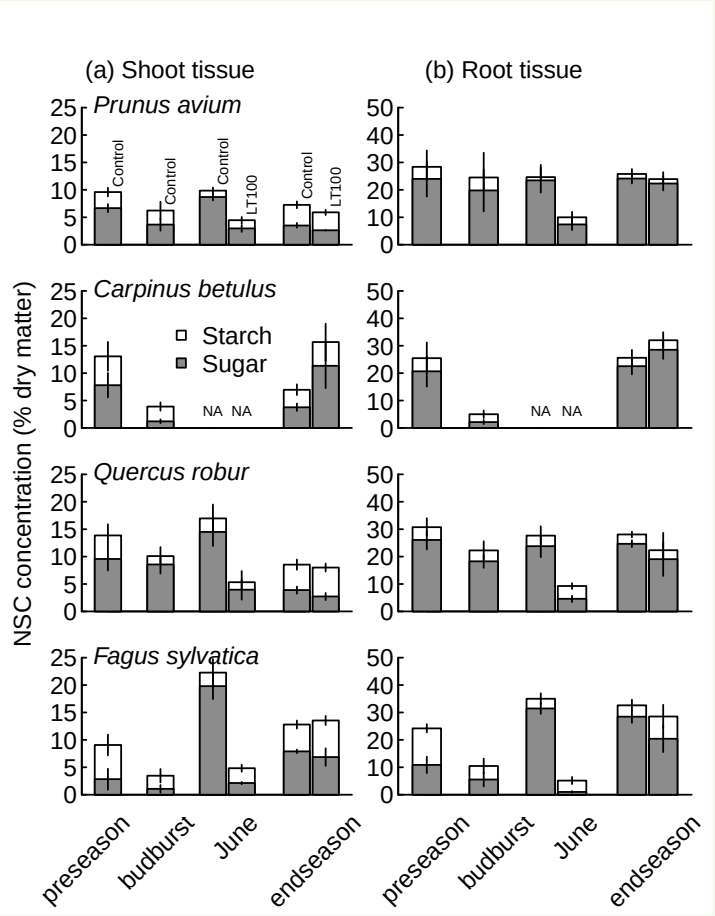


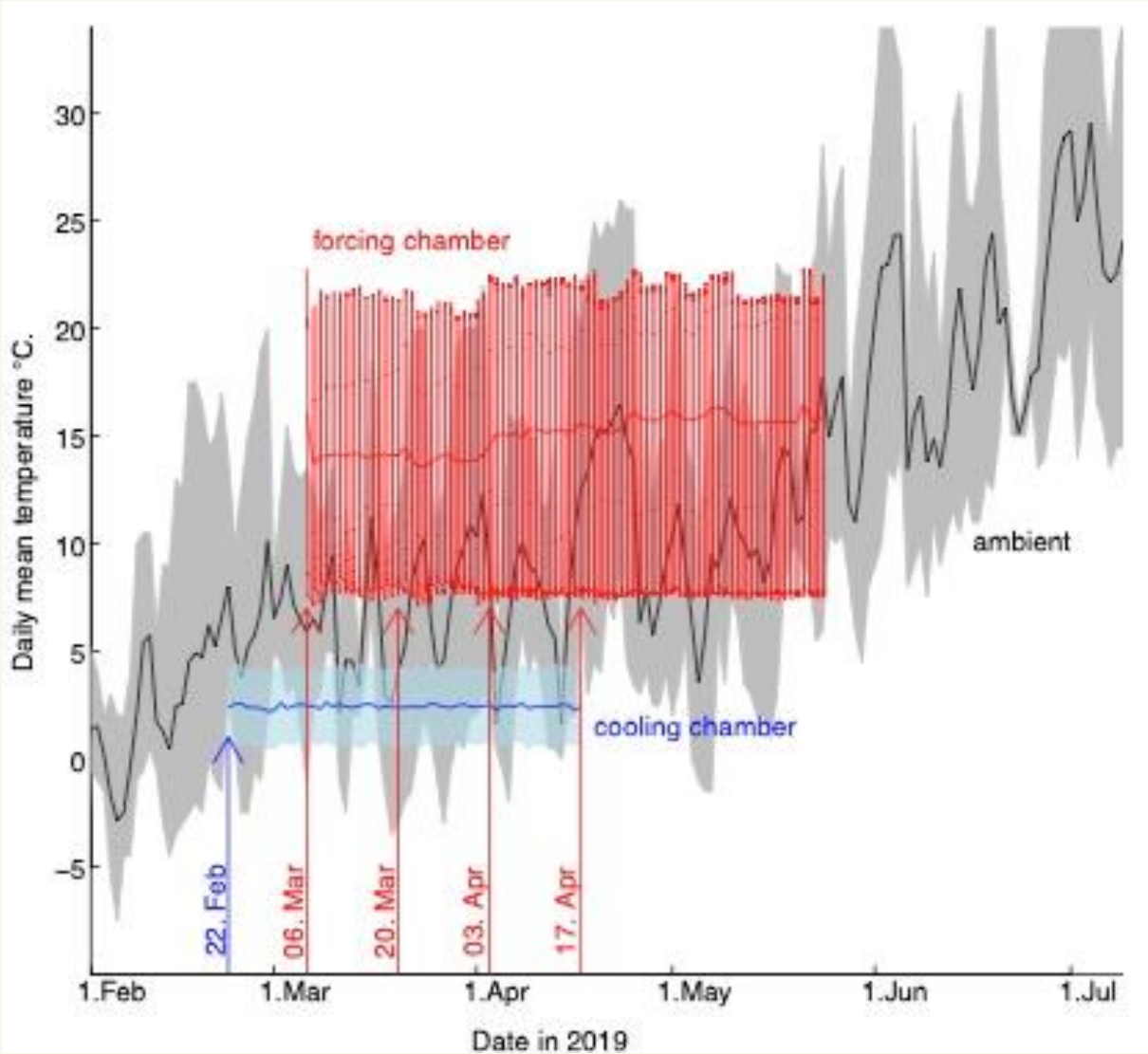
Delayed leaf-out -> advanced senescence

Advanced leaf-out -> delayed senescence

Delayed leaf-out -> delayed senescence


Shoot
Root
Prunus avium
Carpinus betulus
Quercus robur
Fagus sylvatica
Control
LT100
Sugar
Starch
NSC concentration end of season (% dry matter)
17.Mar
26.Mar
23.Apr
24.Mar
14.Apr
29.Apr
04.Apr
21.Apr
05.May
24.Apr
10.May
16.May
Date of leaf−out


(a) Shoot tissue
(b) Root tissue
Prunus avium
Carpinus betulus
Quercus robur
Fagus sylvatica
Control
LT100
Starch
Sugar
NA
NSC concentration (% dry matter)
preseason
budburst
June
endseason


Daily mean temperature °C.
30
25
20
15
10
5
0
−5
forcing chamber
ambient
cooling chamber
22. Feb
06. Mar
20. Mar
03. Apr
17. Apr
1.Feb
1.Mar
1.Apr
1.May
1.Jun
1.Jul
Date in 2019