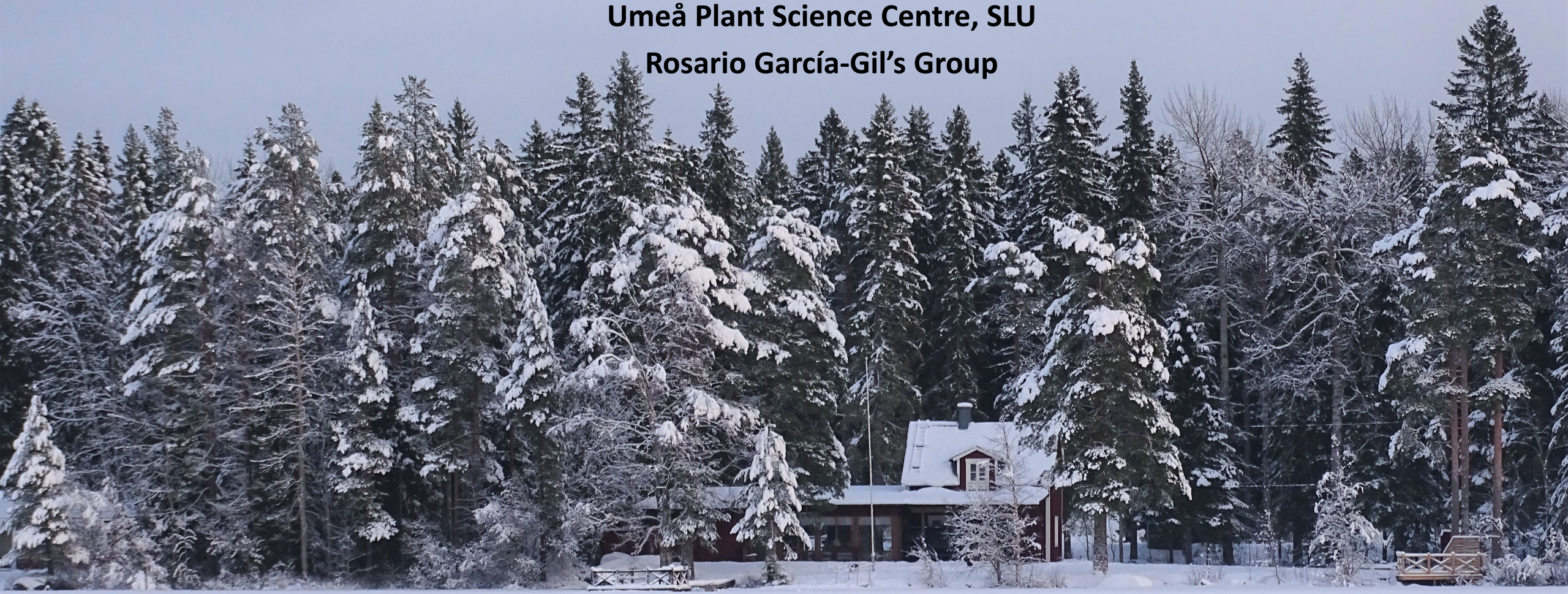
Future Swedish forest feedstocks in the context of climate change

Sonali Ranade

Umeå Plant Science Centre, SLU

Rosario García-Gil's Group



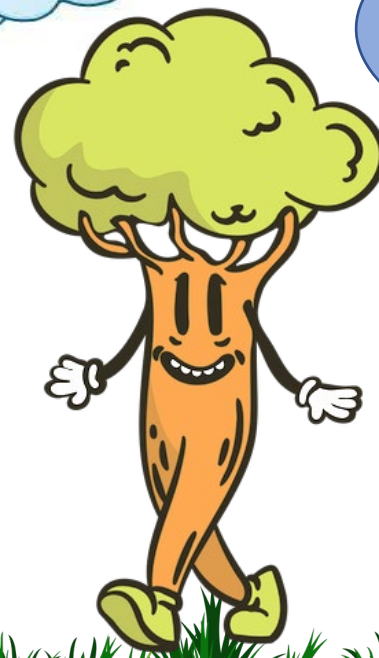
Climate change

Adaptation in forests to local environmental conditions

Light quality

Drought

What if trees could walk?



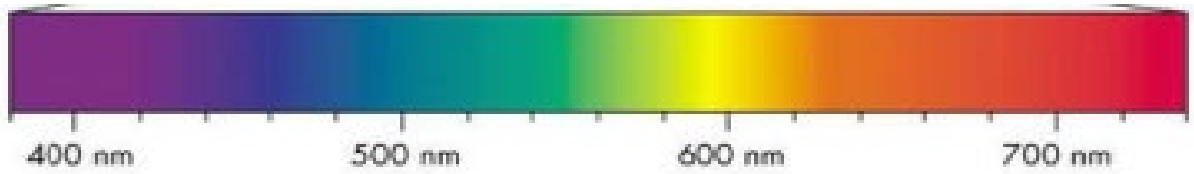
Oh its too much of SHADE here, let me take a walk in the SUN

But trees cannot walk!

So, trees must adapt!

Visible Light

Color	Wavelength
Violet	380–450 nm
Blue	450–495 nm
Green	495–570 nm
Yellow	570–590 nm
Orange	590–620 nm
Red (R)	**620–710 nm**
Far-red (FR)	**710–850 nm**



Visible Light Spectrum

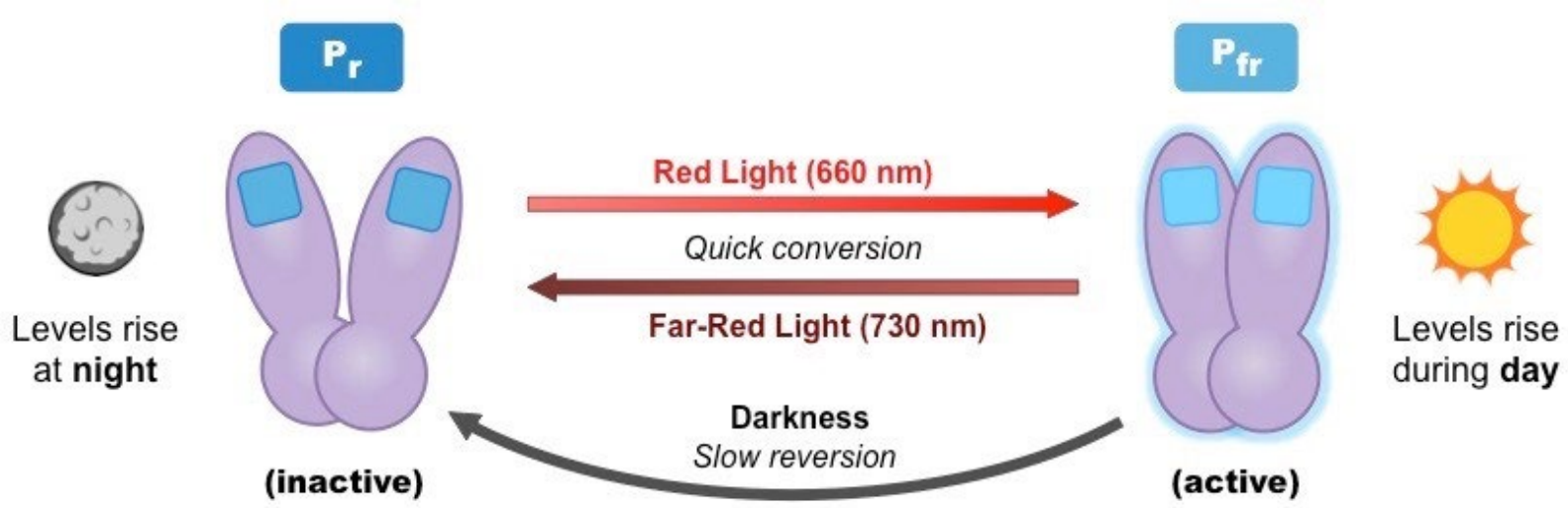
SUN

R: FR ratio is between 1–1.3

SHADE

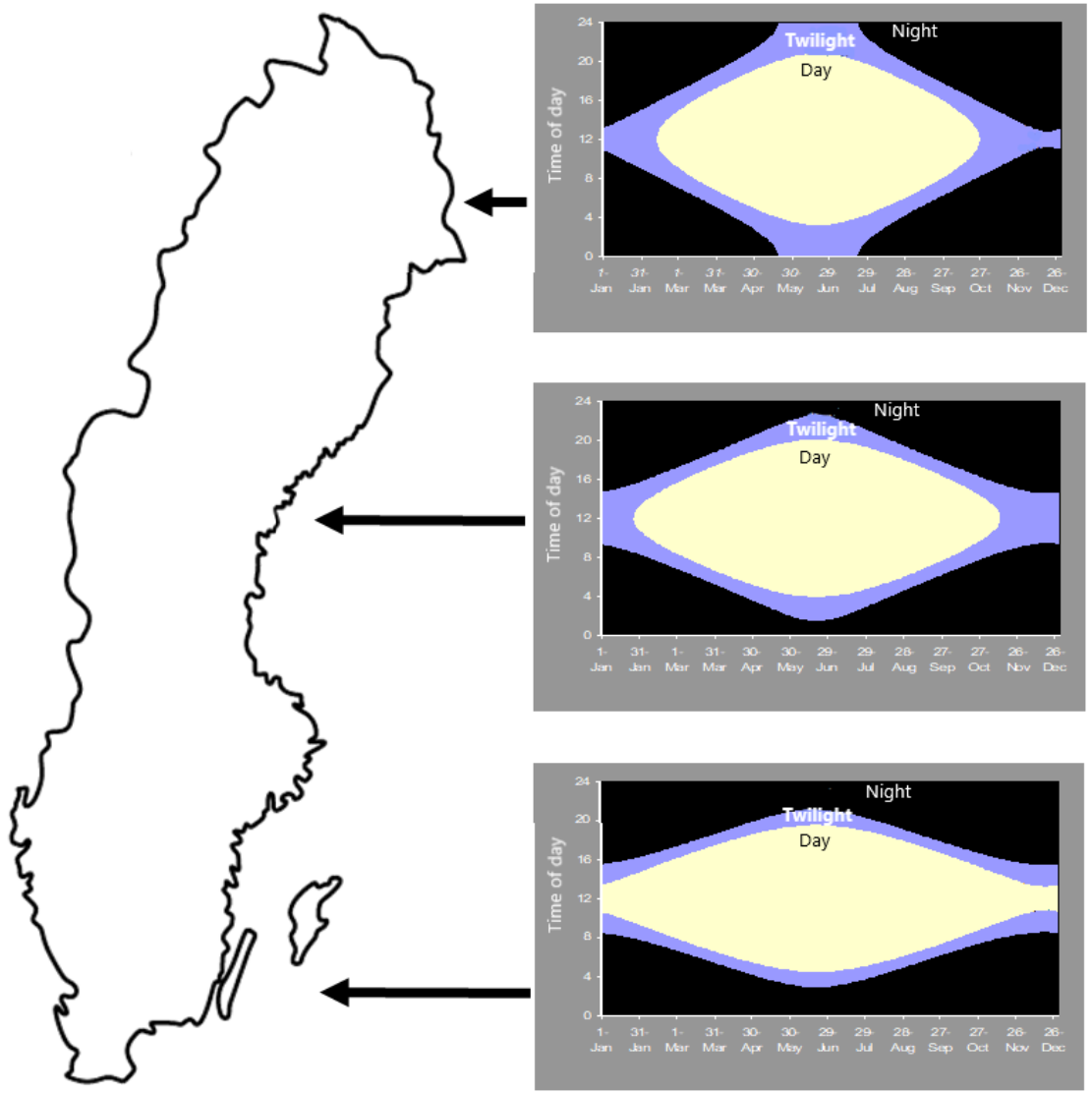
R: FR is between 0.2–0.8

Phytochromes are the central regulators of light pathway (perceive R and FR)



https://ib.bioninja.com.au/higher-level/topic-9-plant-biology/untitled-3/photoperiodism.html

- Light quality differs throughout the year across Sweden
- Northern latitudes receive more amount of FR light or SHADE LIKE condition during growth seasons



SUN

R: FR ratio is between 1–1.3

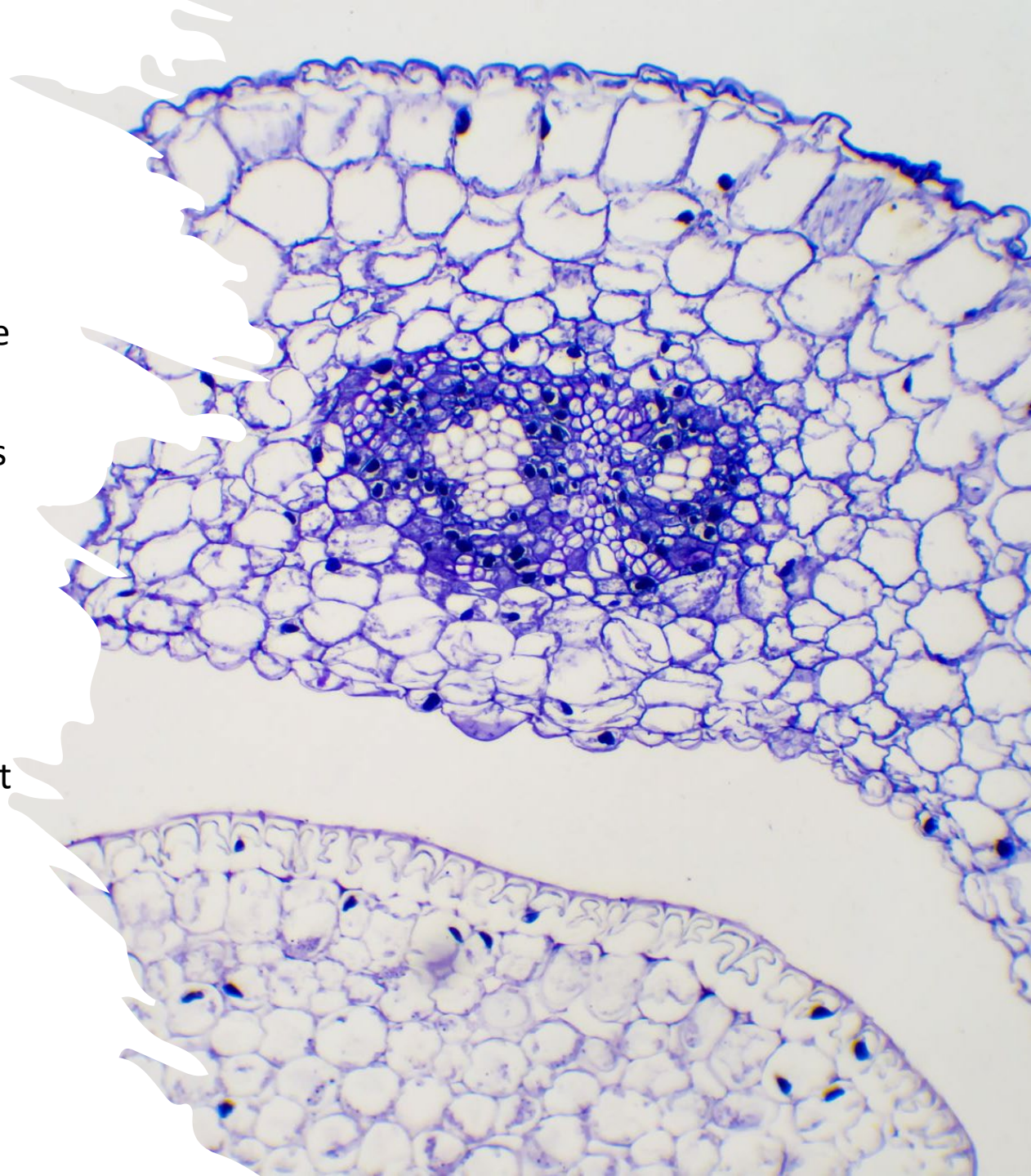
SHADE

R: FR is between 0.2–0.8

Linkosalo, T. & Lechowicz, M.J. 2006, Tree Physiology

Light regulates lignin synthesis

- Lignin – second most abundant polymer, next to cellulose
- Provides structural support, role in **plant defense –** forms barrier
- Low R:FR ratio or **SHADE decreases lignin** production in angiosperms
- Response to **SHADE** in angiosperms – weaker stem, plant vulnerable to pathogens



WHAT IS CLINE?

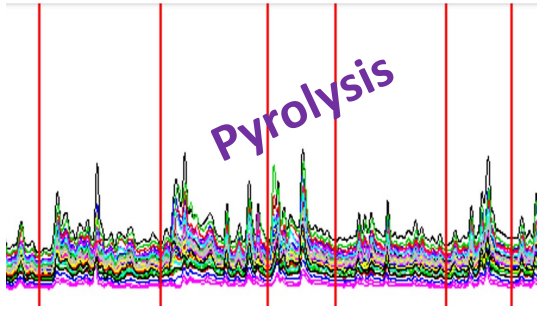
A cline is a measurable gradient of a single trait/character in a particular species, across its geographical range.

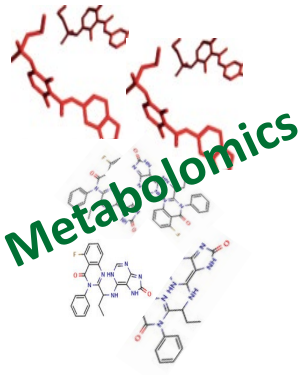
Growth experiments

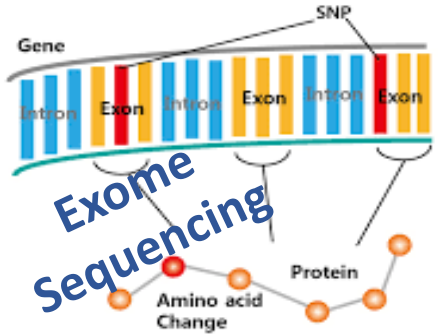
Percival cabinet: 85% humidity and 22 °C

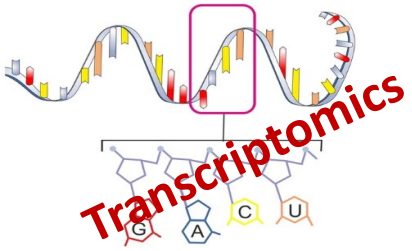
	Light conditions
SHADE	R:FR 0.2 (36 µmol m^{-2} s^{-1})
	R (6 µmol m^{-2} s^{-1}):FR (30 µmol m^{-2} s^{-1})
SUN	R:FR 1.2 (65 µmol m^{-2} s^{-1})
	R (35 µmol m^{-2} s^{-1}):FR (30 µmol m^{-2} s^{-1})

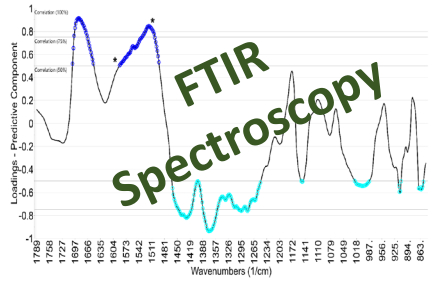
Phenotyping



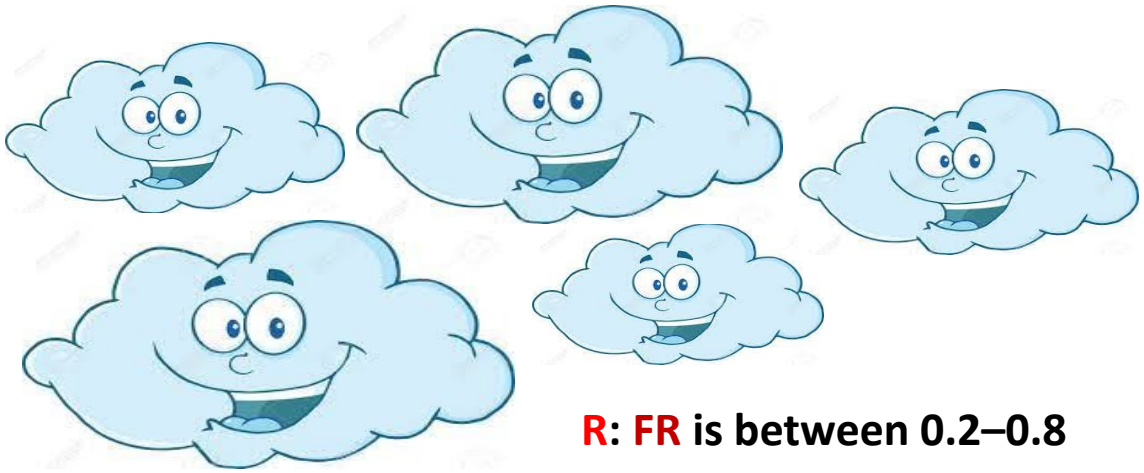






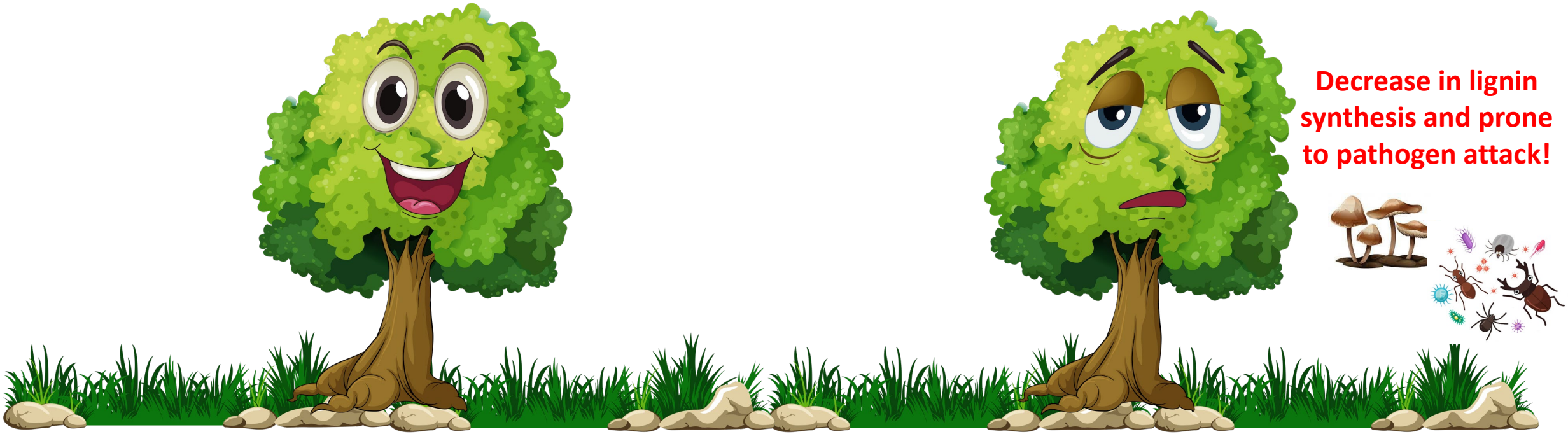


R: FR ratio is between 1–1.3



R: FR is between 0.2–0.8

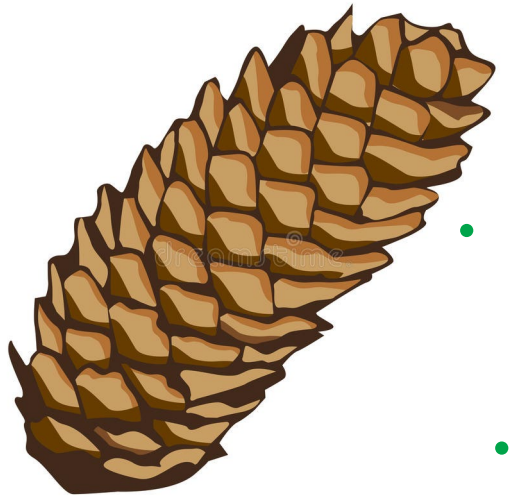
(Also, under canopy shade)



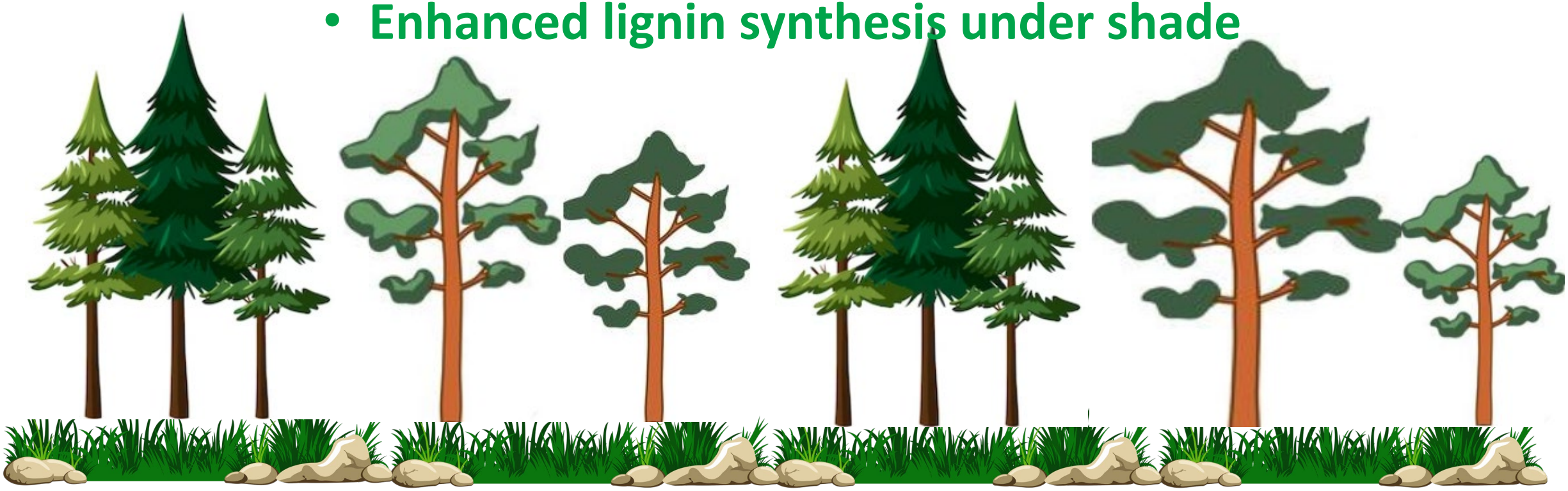
Decrease in lignin synthesis and prone to pathogen attack!

Wu et al., 2017; Hussain et al., 2019

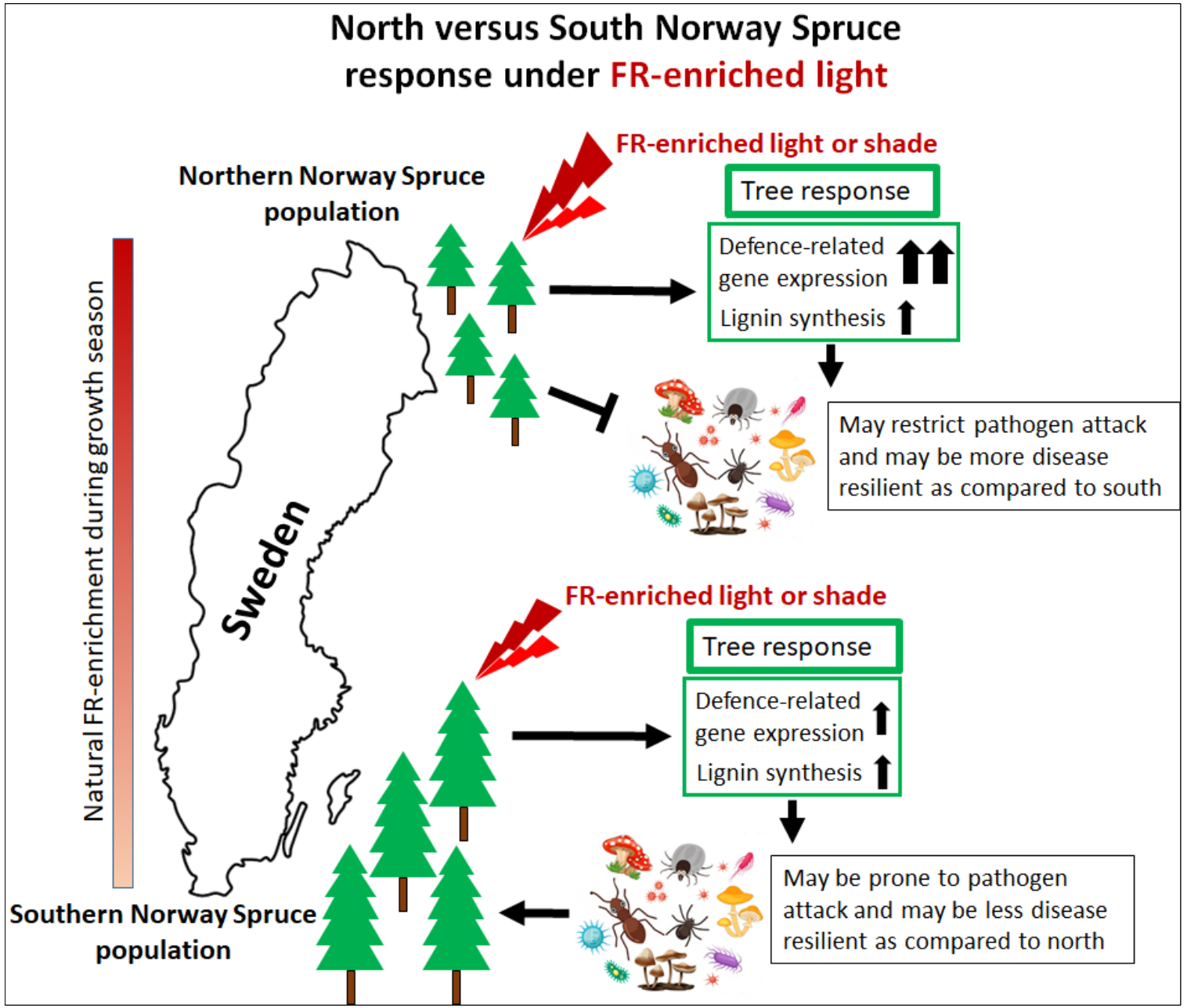
Conifers are different!!!!
HOW??



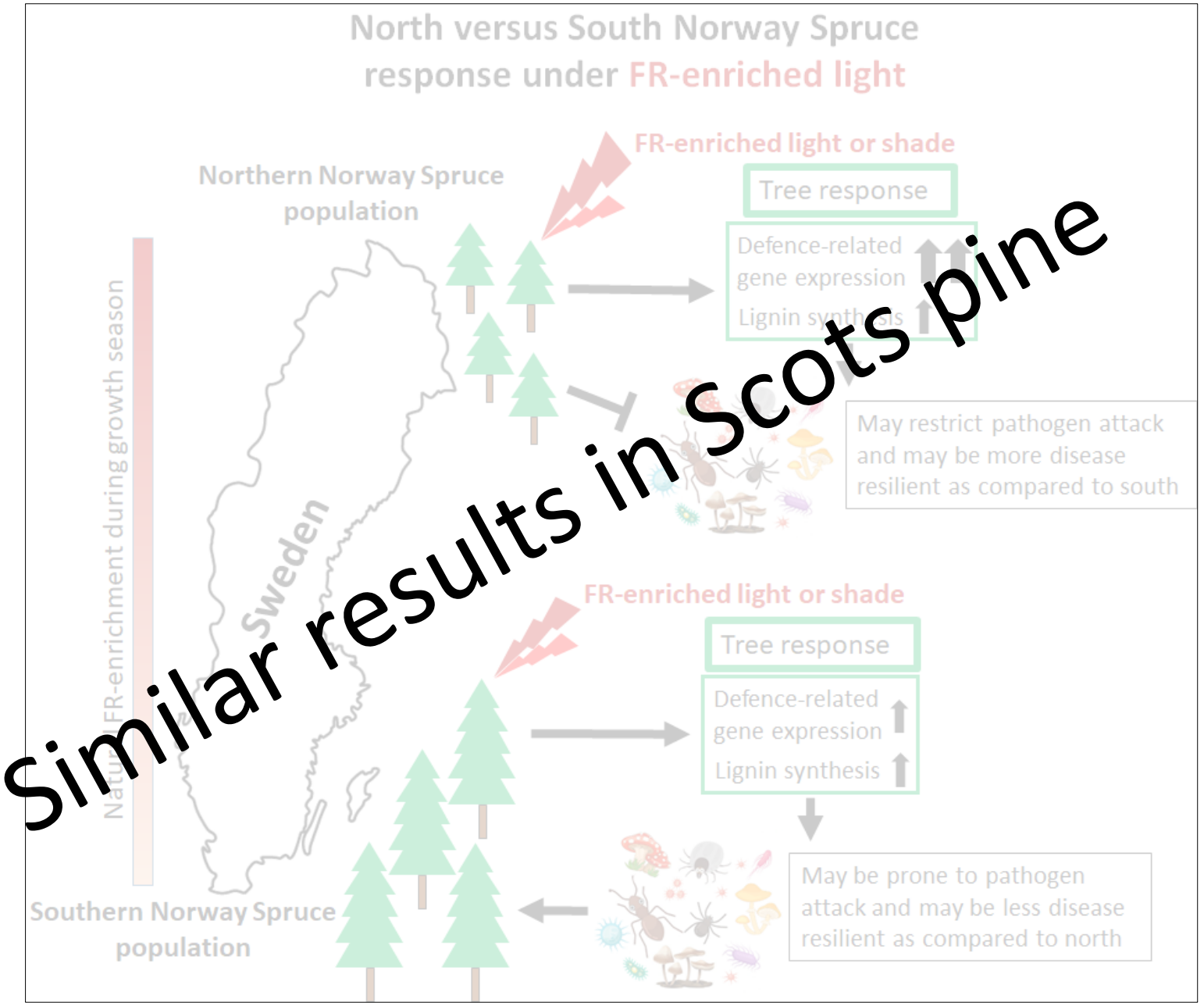
- Norway spruce (shade tolerant) and Scots pine (shade intolerant) show cline for requirement of **FR** light to maintain growth: Northern trees require more **FR**
- Norway spruce shows clinal variation in the level of shade tolerance
- **Enhanced lignin synthesis under shade**



Clapham et al. 1998, 2002, Physiologia Plantarum; Ranade & Garcia-Gil. 2013, Tree Physiology; Ranade & Garcia-Gil. 2021, Planta



Ranade et al. 2022, Plant Cell & Environment

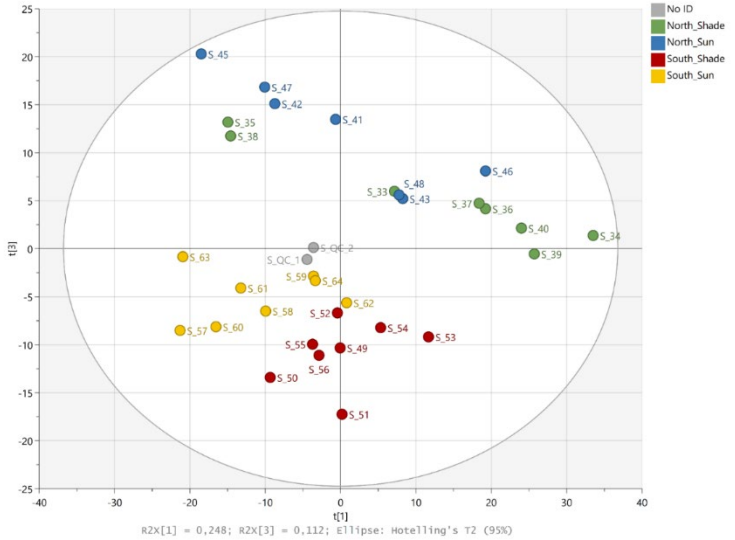


Similar results in Scots pine

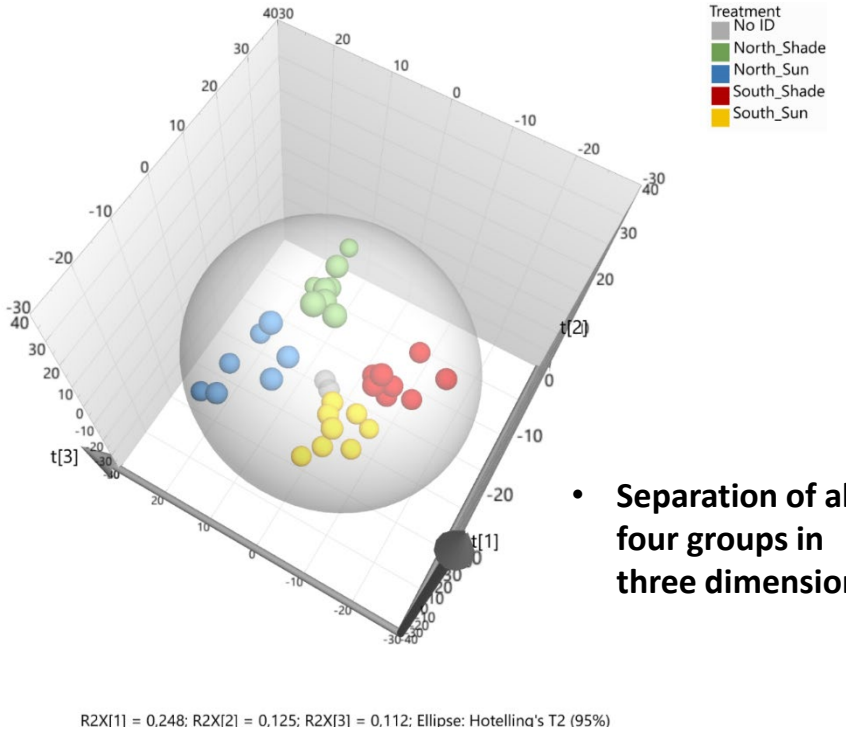
Ranade et al. 2022, Physiologia Plantarum

Metabolomics
PCA shows separation between all groups, Spruce

Blank + S44 removed (N = 33), targeted + untargeted metabolites (K = 799)



- Clear separation between ”Northern” and ”Southern” samples
- ”Southern Sun” and ”Southern Shade” groups also separated
- ”Northern” samples show no strong separation between ”Sun” and ”Shade” in PCA



- **Separation of all four groups in three dimensions**

Response to drought in Norway spruce

- Experiment done in greenhouse conditions

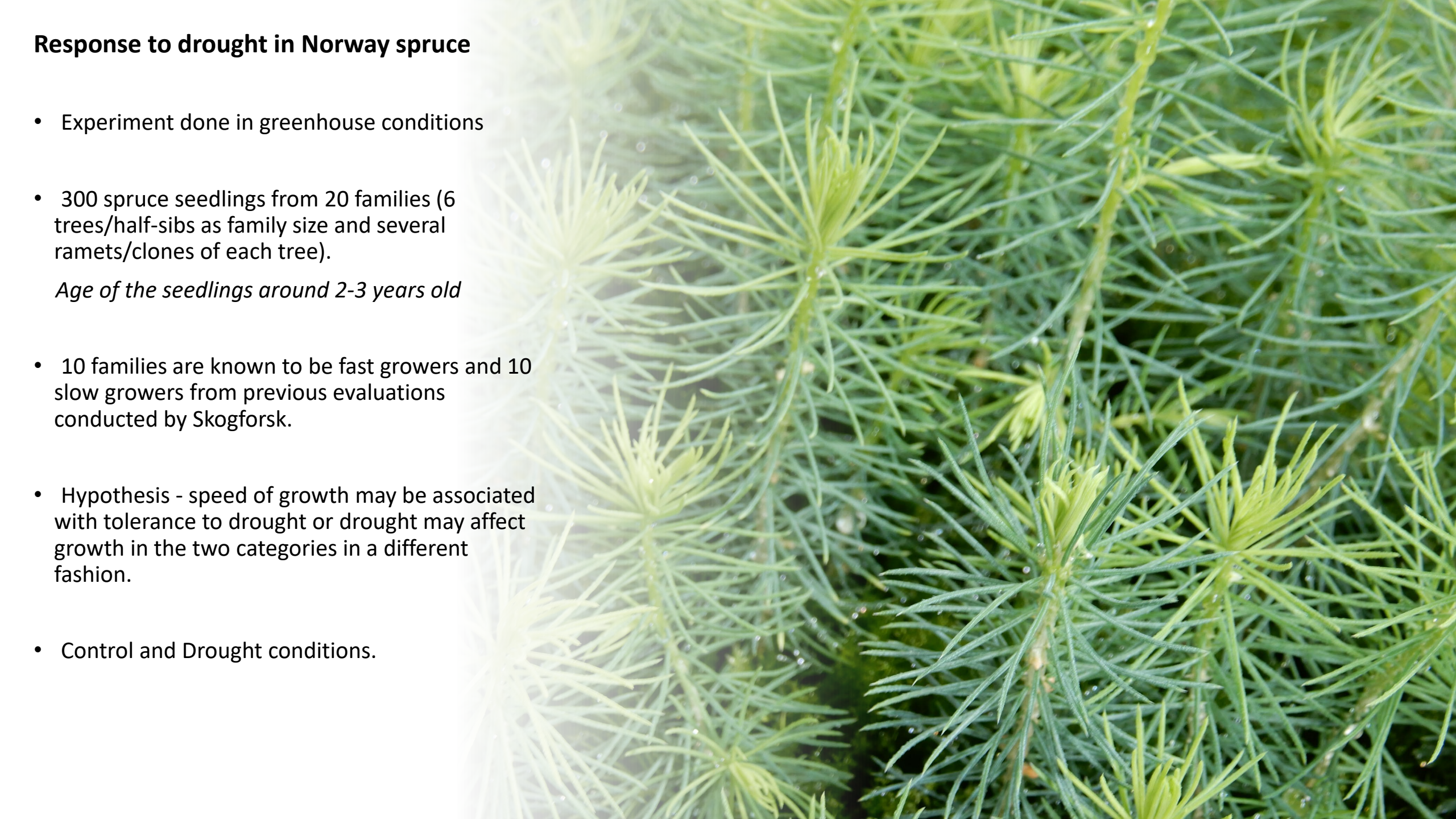
- 300 spruce seedlings from 20 families (6 trees/half-sibs as family size and several ramets/clones of each tree).

  Age of the seedlings around 2-3 years old

- 10 families are known to be fast growers and 10 slow growers from previous evaluations conducted by Skogforsk.

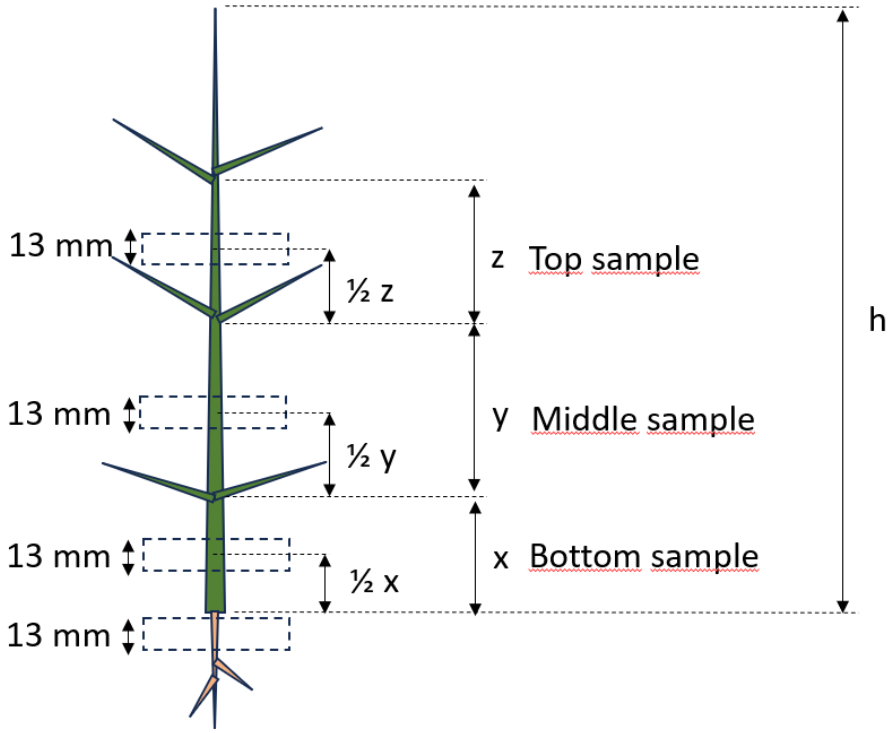
- Hypothesis - speed of growth may be associated with tolerance to drought or drought may affect growth in the two categories in a different fashion.

- Control and Drought conditions.

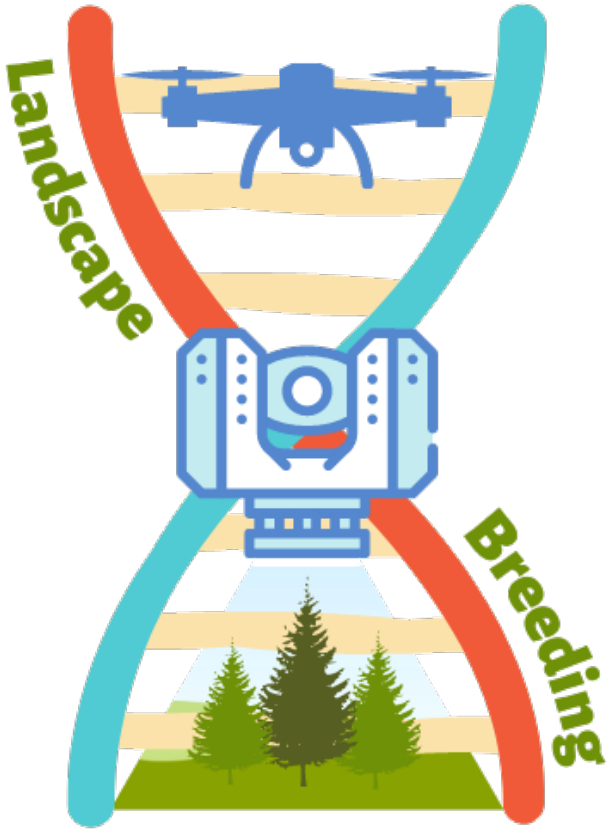


Response to drought in Norway spruce

- Seedlings were maintained in green house for six months
- Development/growth was followed in the seedlings by measuring the length
- Metabolomics
- Wood properties (RISE will conduct the analyses)
  - Near-infrared (NIR) spectroscopy (lignin, cellulose and hemicellulose content)
  - Silviscan (wood density, microfibril angle)

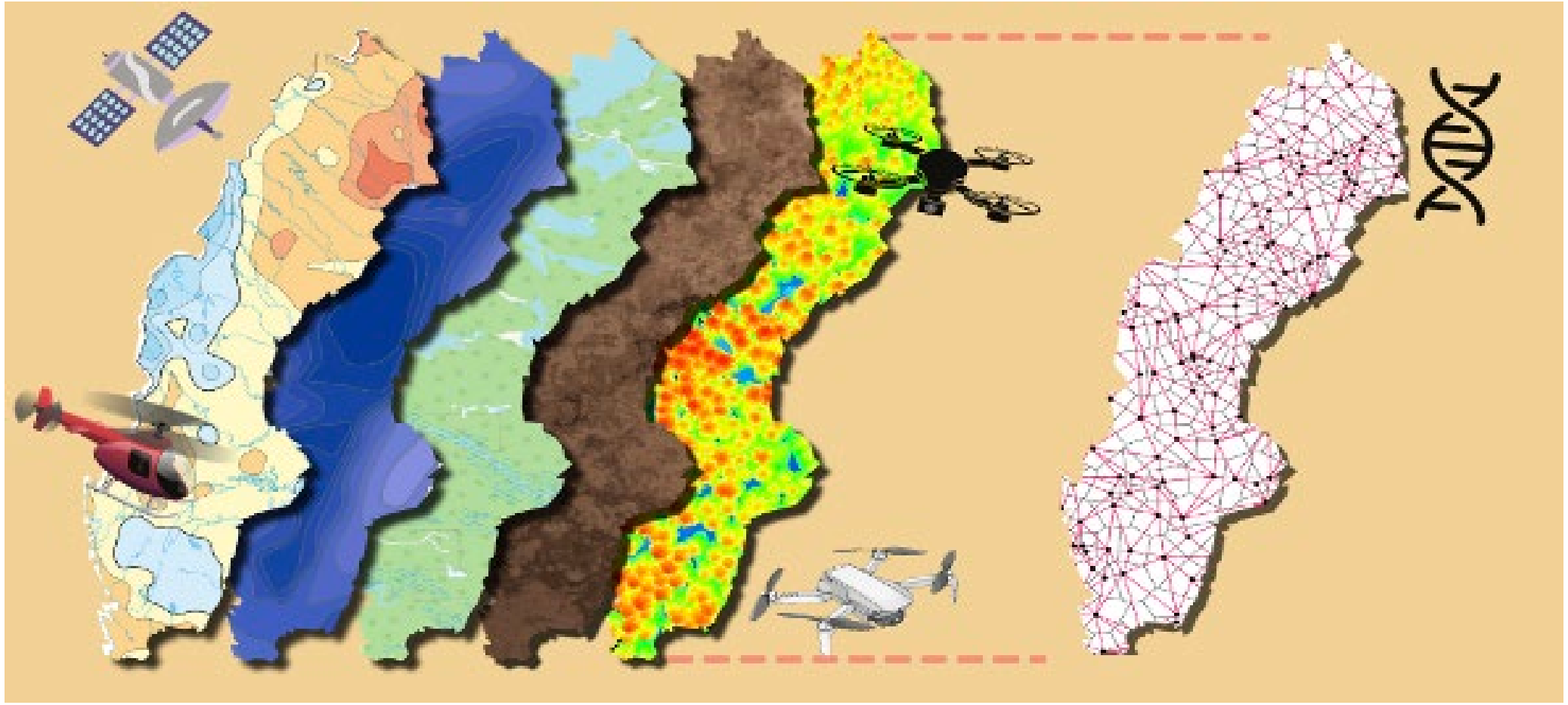


Landscape Breeding: A new paradigm in forest tree management



Swedish Foundation for Strategic Research

P = G +E



REMOTE SENSING

PHENOTYPE (P) and ENVIRONMENT (E)

G-MATRIX

GENOTYPE (G)

Acknowledgements

Rosario Garcia-Gil
&
all group members

Nicolas Delhomme
UPSC Bioinformatics Facility

András Gorzsas
Vibrational Spectroscopy Core Facility (ViSp)

Junko Takahashi-Schmidt
Biopolymer Analytical Platform (BAP)

Annika Johansson
Swedish Metabolomics Centre (SMC)

Kate Bennett
Computational Analytics Support Platform (CASP)

Greenhouse Team
Technical & IT support

Thank You