IUFRO XI International Workshop on Uneven-aged Silviculture: Challenges for increasing adaptability

UACh

Transforming even-aged coniferous stands to uneven-aged stands: an opportunity to increase tree species diversity?

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Even-aged to uneven-aged

- Coniferous plantations (monoculture), still cover large areas in Europe
  - 50% of forest areas in Belgium
  - Traditionnally, these stands are managed with clear-cuts and plantations
- Silviculture avoiding clear-cutting is more and more encouraged or even imposed by regulation
  - Pro-Silva silviculture must be applied in state-owned forest in Belgium
  - Clear-cuts are forbidden in peri-urban forests around Paris, France
  - …
- But very few guides for practionners…
  - How long does it take to reach an equilibrium state and to harvest the planted trees?
  - What is the forest productivity during the transformation period?
  - What will be the composition (and resilience) of future uneven-aged stands?

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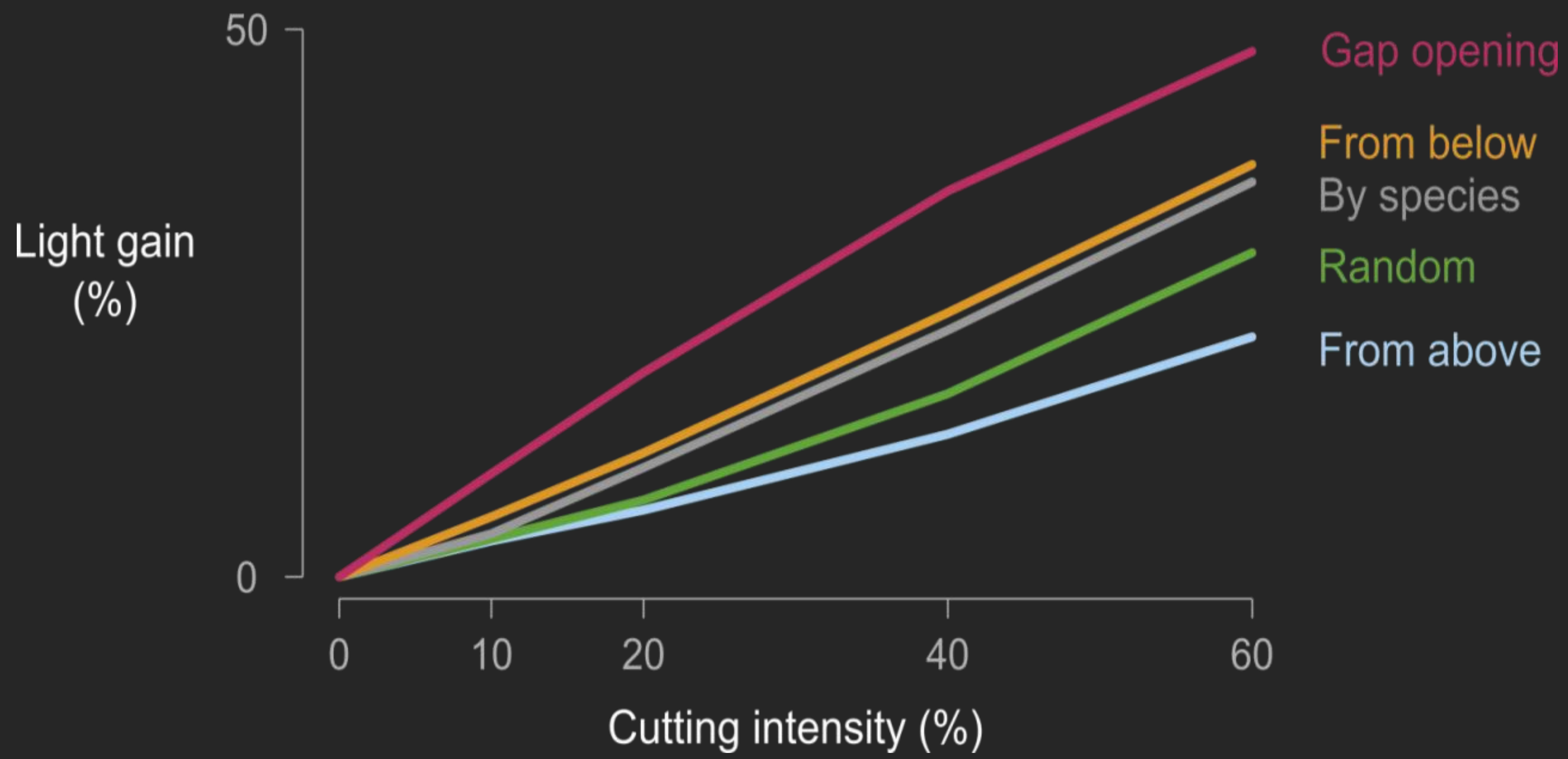

Ligot et al. (2016) Can. J. For. Res. 46 (7)

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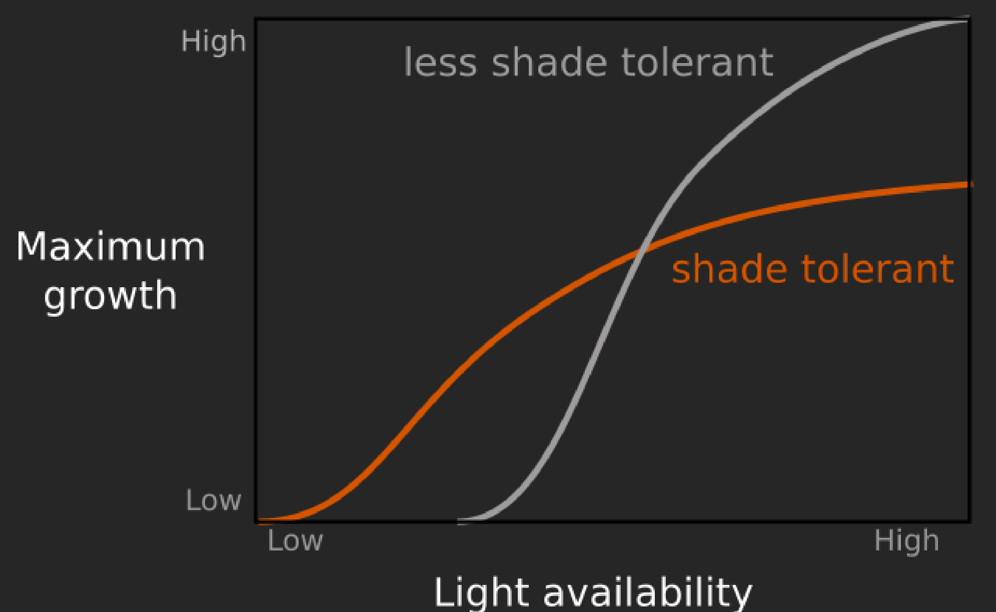
- A limiting factor under continuous cover forestry
- Understory light levels can be controlled by partial cuttings
- Drive inter-specific competition



adapted from Smith et Huston (1989) *Vegetatio 83:49-69*

Understory light is assumed to be a key factor of natural regeneration

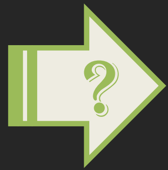
- A limiting factor under continuous cover forestry
- Understory light levels can be controlled by partial cuttings
- Drive inter-specific competition
- The apical dominance ratio has been suggested to be a good indicator of understory light conditions for some species

$$\text{ADR} = \frac{\textit{terminal shoot length}}{\textit{Longest lateral shoot length}}$$

Research questions

- Can we expect that tree species diversity will increase in stands managed without clear-cut? What are the light conditions that best promote species diversity? Can we control it?

- Is the Apical Dominance Ratio (ADR) a good indicator of understory light for that purpose?



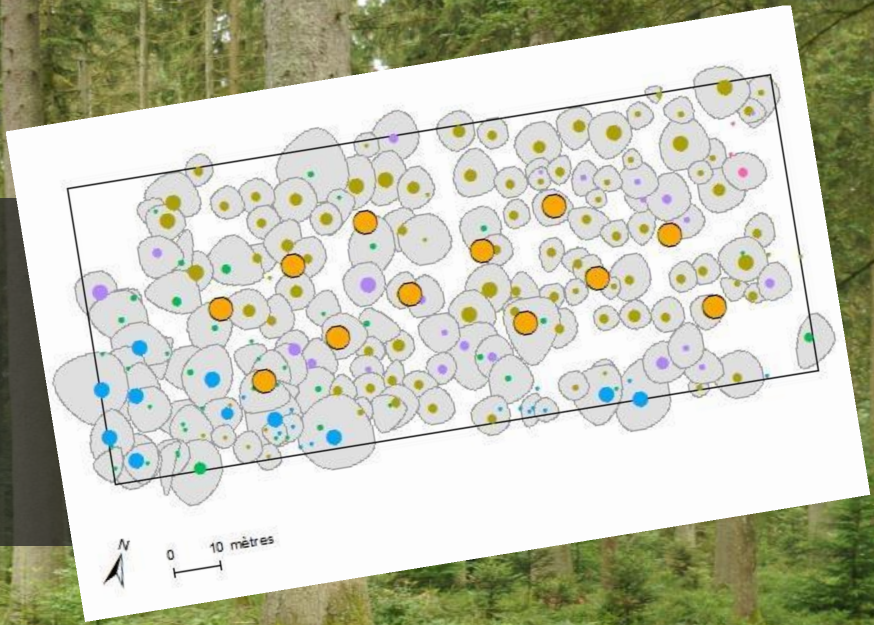
Study area

- **9 coniferous stands in Belgium at 400-600 m a.s.l**

	Young 35 year old	Mature 60 year old	Old 80-150 year old
Spruce *Picea abies* (L.) Karst			
Douglas fir *Pseudotsugae menziesii* (Mirb.) Franco			
Mixed *Picea abies* (L.) Karst *Pseudotsugae menziesii* (Mirb.) Franco *Larix* sp. *Abies alba* Mill. *Tsuga heterophylla* (Raf.) sarg.			

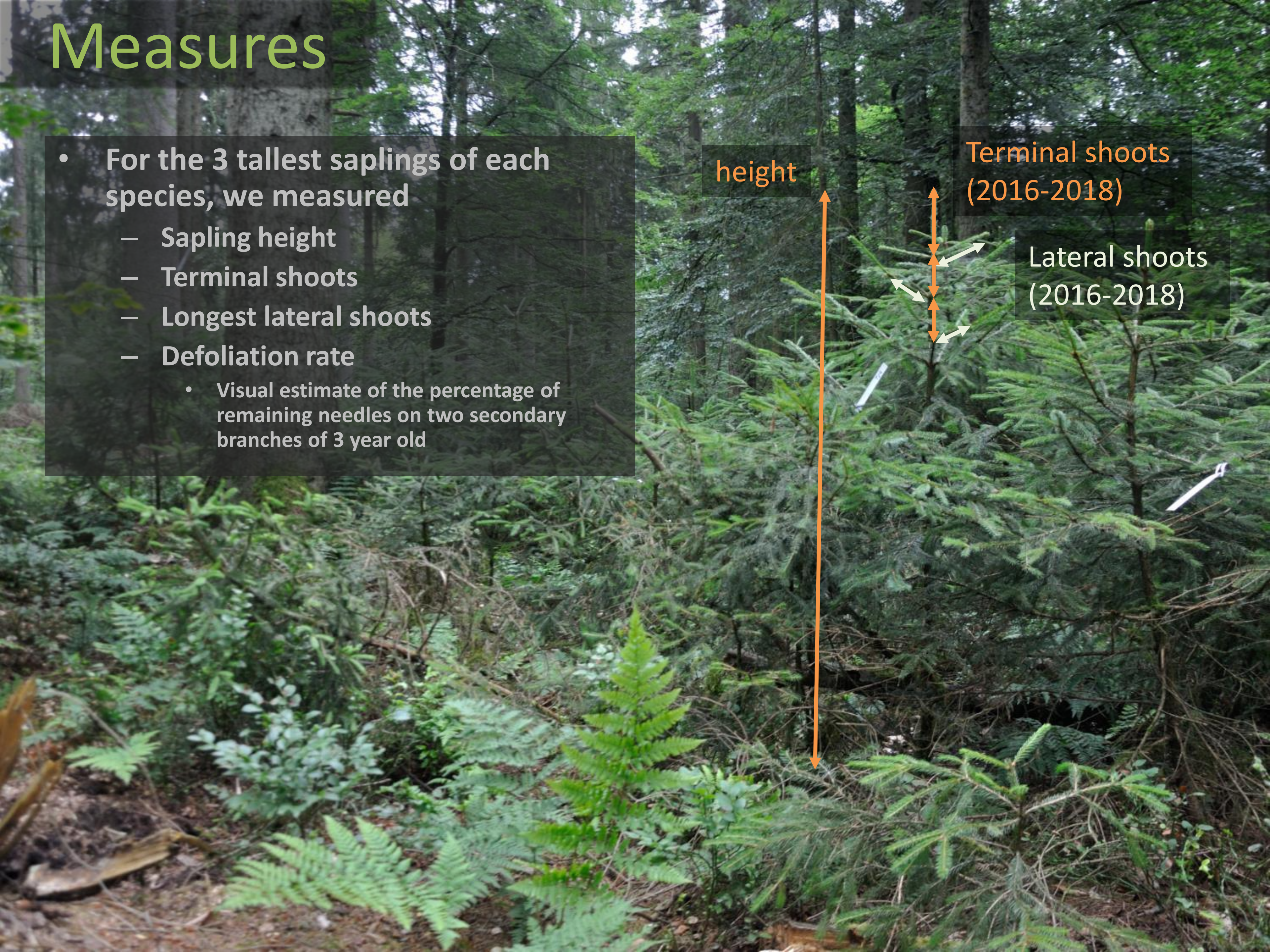
Measures

- 1 ha plots in each site
- 12 circular subplots of 3-m radius

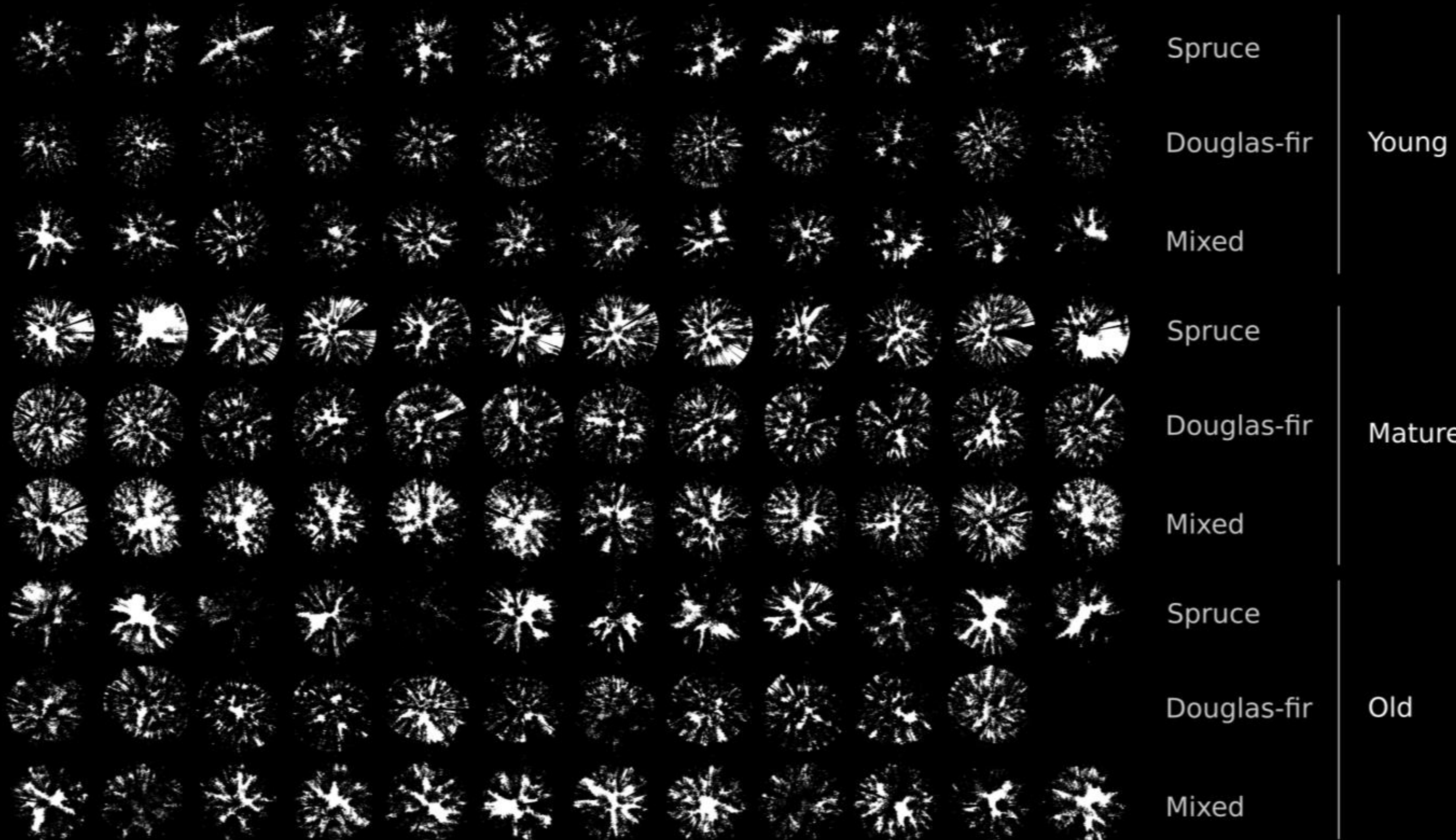


Measures

- For the 3 tallest saplings of each species, we measured
  - Sapling height
  - Terminal shoots
  - Longest lateral shoots
  - Defoliation rate
    - Visual estimate of the percentage of remaining needles on two secondary branches of 3 year old

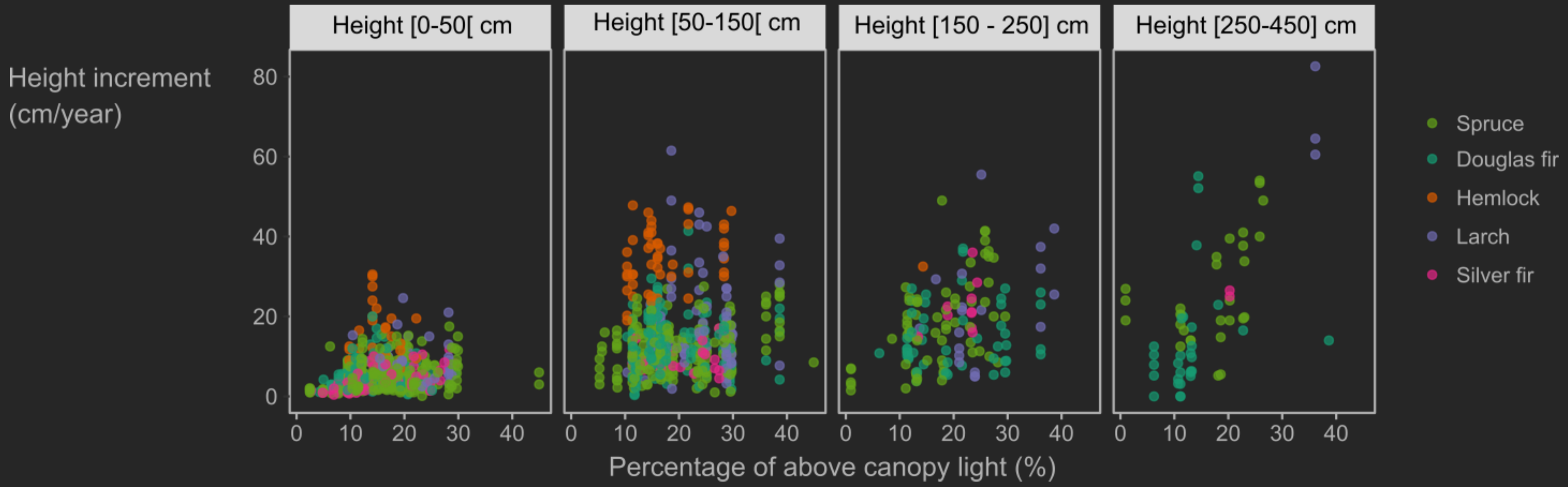


In spring 2018, 107 hemispherical photographs to measure to percentage of above canopy light (PACL), taken above the regeneration of each subplot (with a telescopic pole and an auto-stabilized device)



Summary statistics

- n = 1356 measures of terminal shoots of 565 saplings
  - 250 spruces
  - 141 douglas firs
  - 56 larches
  - 58 silver firs
  - 54 hemlocks
- Height up to 445 cm
- PACL varying from 1% to 45%



Modelling terminal shoot lenght

Non-linear mixed model fitted with the restricted maximum of likelihood

$$terminal\ shoot\ length_{i,j,k,l} = (a + \alpha_i)\ height^{b}_{i,j,k,l}\ PACL^{c}_{i,j,k} + \varepsilon_{i,j,k,l}$$

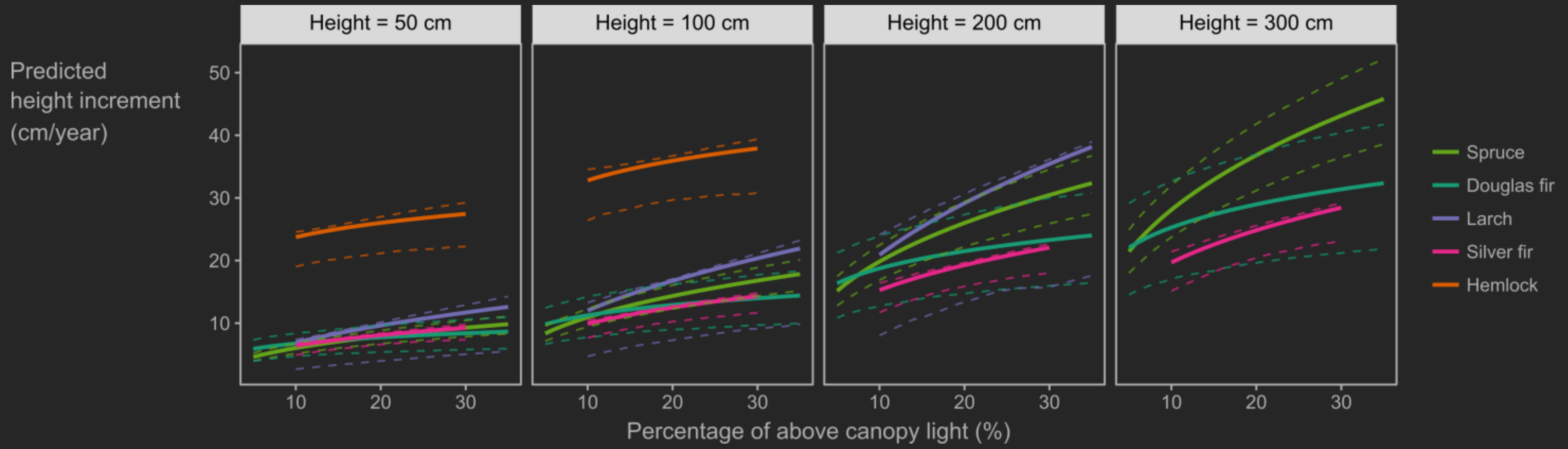
with a, b, c the fixed parameters
α a random plot effect : $\alpha \sim N(0,\sigma_\alpha)$
ε the random residual error : $\varepsilon \sim N(0, \sigma_\varepsilon)$

Modelling terminal shoot lenght

- Terminal shoot logically increased with height and PACL

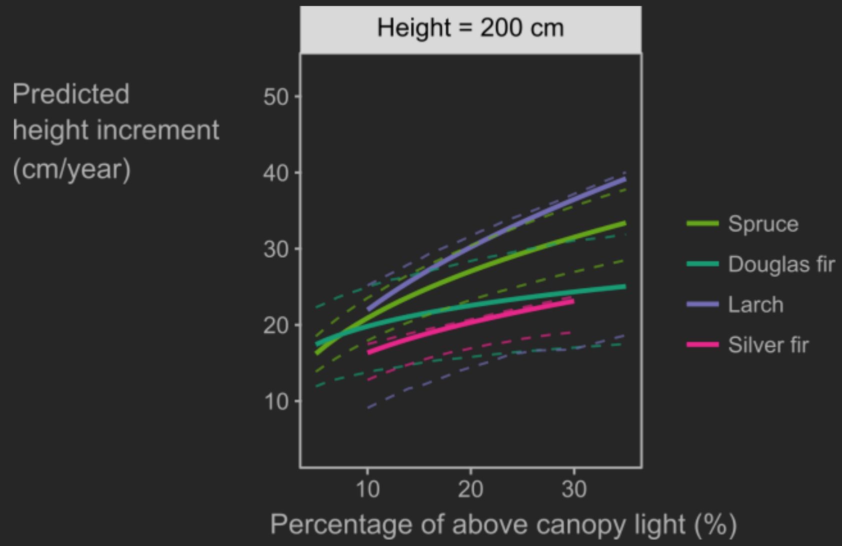
- Western hemlock, a very shade tolerant species, had terminal shoot about three times longuer than that of the other species in all observed light conditions (no saplings of height ≥ 200 cm observed)

- Species ranking according to the predicted height increment was the same in all light conditions



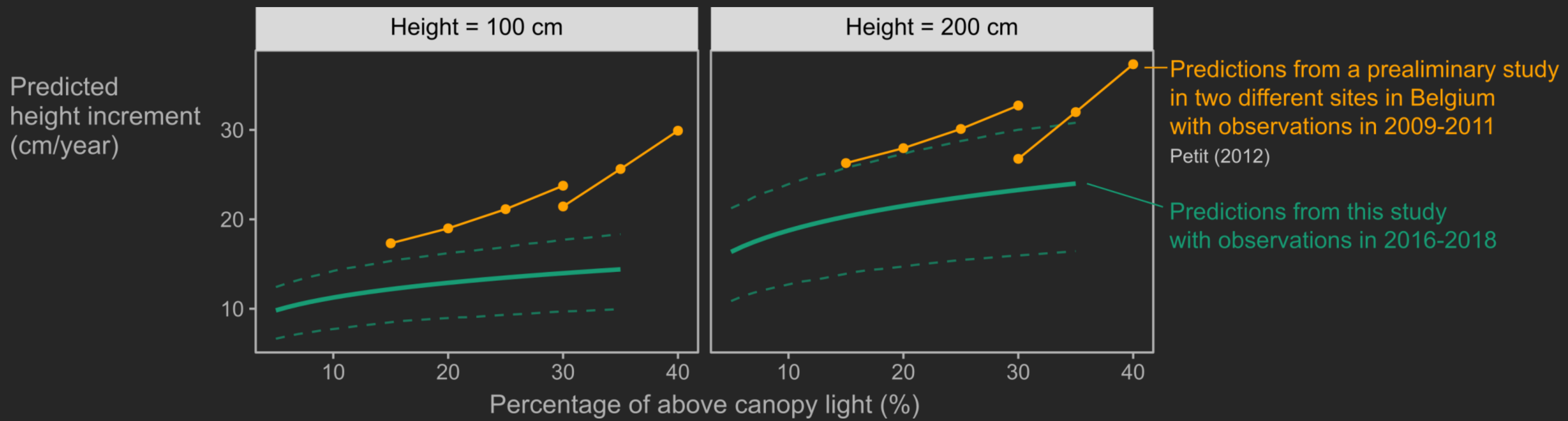
Modeling terminal shoot lenght

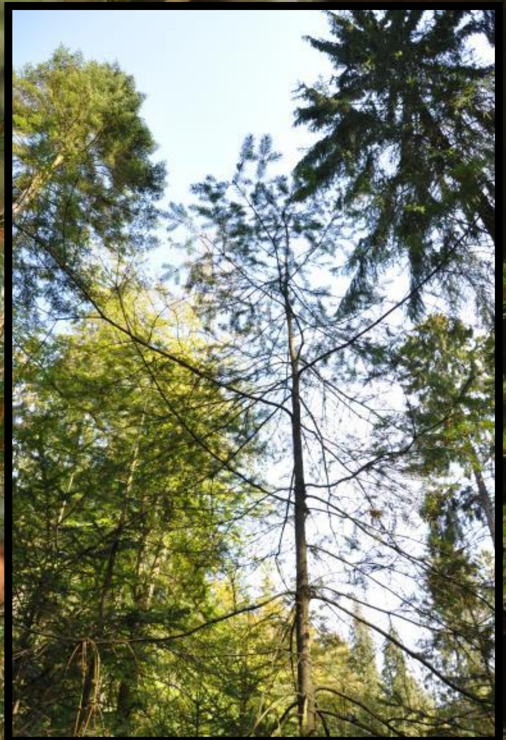
- Not considering Western Hemlock:
  - In low light conditions, all species grow at relatively similar height growth rates
  - In high light conditions, some species can grow faster than others. They are by order of decreasing height increment:
    1. Larch (shade intolerant)
    2. Spruce (shade tolerant)
    3. Douglas fir (less shade tolerant)
    4. Silver fir (very shade tolerant)



What's wrong with the Douglas fir?

- We expected larger height increment and stronger response to light





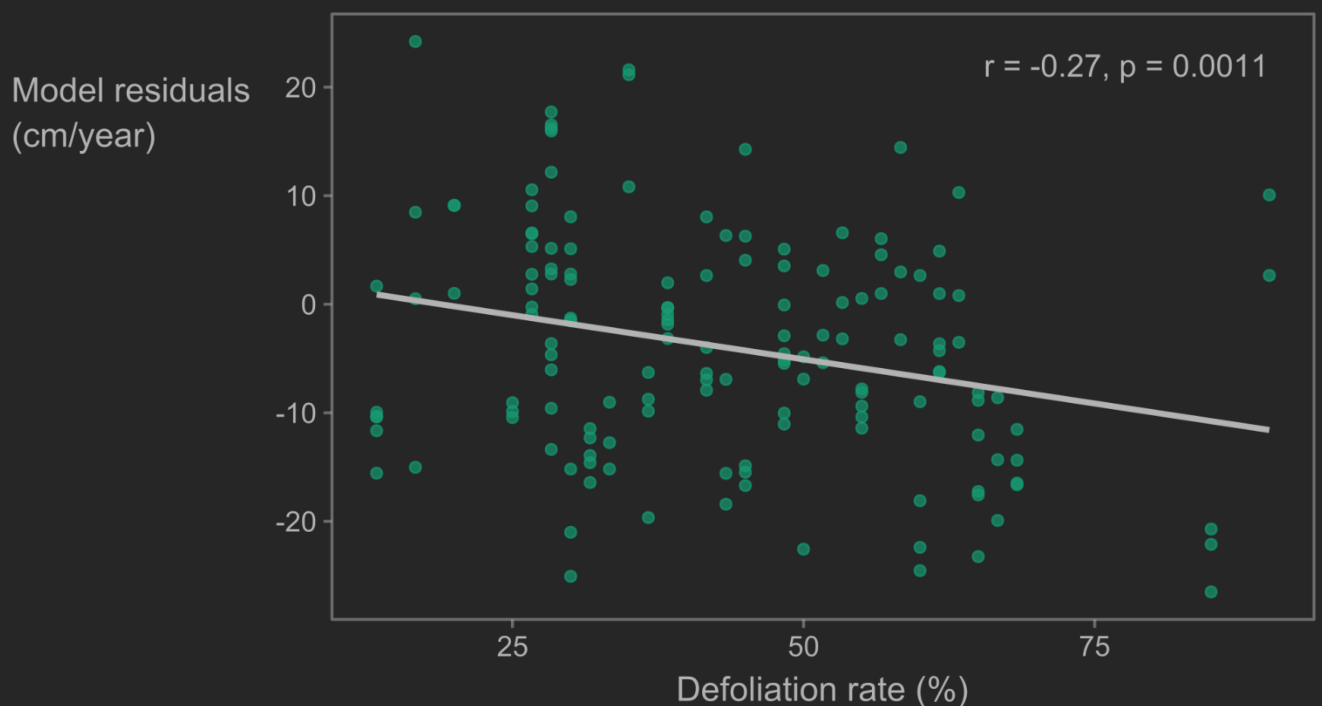
Increased sensitivity to different pest and pathogens in the recent years (abundance of necroses and important defoliation):

- *Phaeocryptopus gaeumannii* (Swiss needle cast)
- *Sirococcus conigenus*
- *Contarinia pseudotsugae*
- …

Defoliation rate and douglas fir growth

- In average, douglas fir saplings had a defoliation rate of 50% while silver fir and spruce had a defoliation rate of about 20%.

- We found a weak but significant correlation between the residuals of the height increment model for douglas fir and the defoliation rate



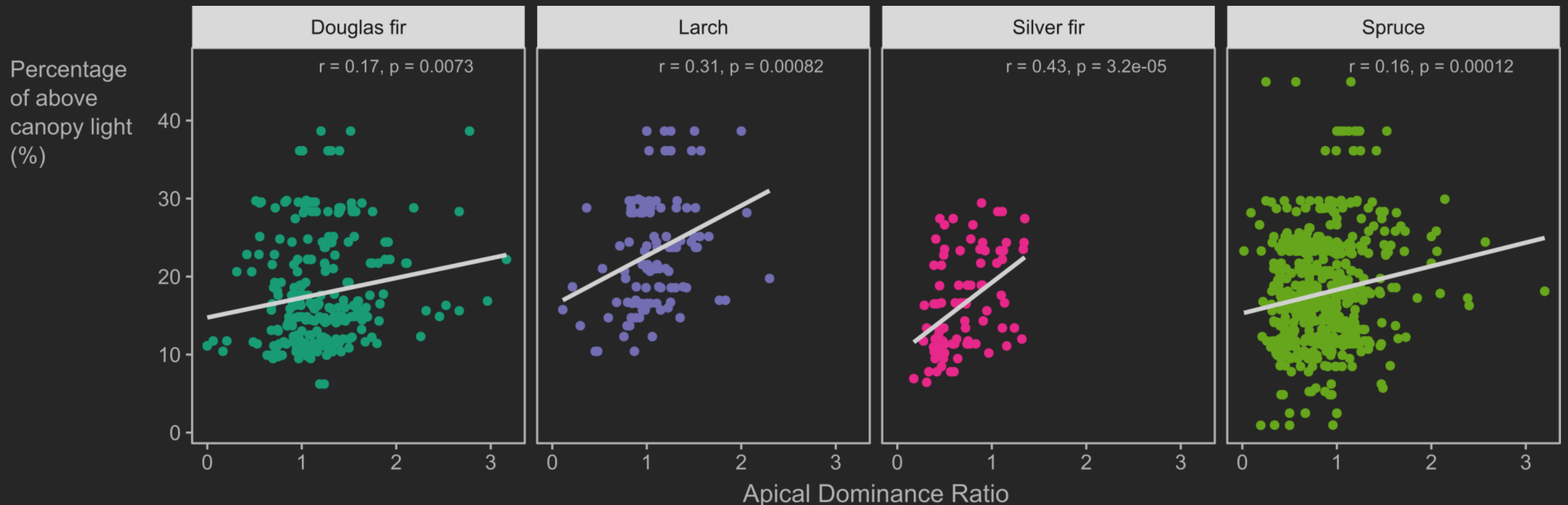
ADR: a good indicator of understory light?

- For all species but Western Hemlock, the relationships between ADR and PACL are significant but weak : $R^2 < 19\%$

- PACL estimate at subplot center cannot be accurate enough to estimate the light absorbed by saplings (sometimes 3m away from the subplot center)

- Other factors likely interacts (e.g. pathogens)

- Picking one random sapling and estimating its ADR, will likely not provide accurate measure of understory light (within the studied range of light conditions (1-30%))



Is the conversion from even-aged to unevenaged an opportunity to increase future stand diversity?

- Hemlock regeneration generally outcompeted other tree species. This thread can likely not be avoided by controlling understory light (whithin the range of light conditions observed with continuous cover forestry).

- Natural regeneration of Douglas fir in Belgium suffers from different pest and pathogens which likely reduce its competitivity and future abundance.

- Maintaining closed canopies can be used to reduce the vigor of the most vigorous species and increases the probability of less vigorous species to be recruited.


Thank you !
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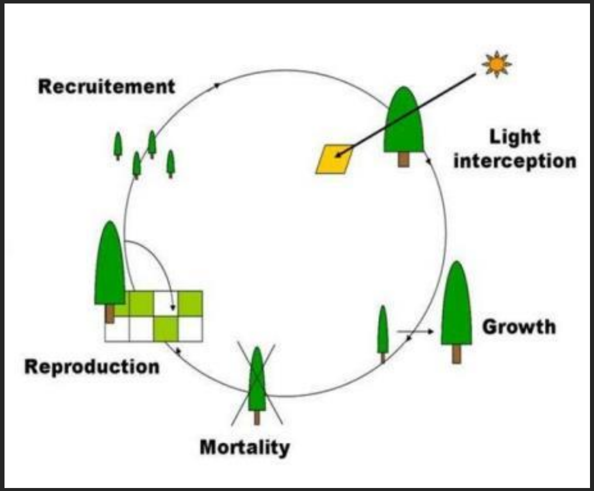
Perspectives

- Implement these models in a forest dynamics simulator to simulate the conversion of even-aged to uneven-aged structure and provide silvicultural guides



Samsara2 model
Courbaud et al. (2015) Ecol. Model. 314

- Continue evaluating regeneration dynamics and in particular sapling and young tree survival