

# Boreal forest: effects of canopy opening on the relationship between trees and the cryptogam layer

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## Context:

**Long term opening of forest stands** on sites characterized by extreme conditions of drainage :

- Excessively drained sites, on coarse-grain deposits.



**1** Canopy opening over the long-term

**2** Expansion of the moss/lichen layer

- Poorly drained sites, on fine grained deposits.



**3** Shift in the composition:

Feather mosses are replaced by **Sphagnum** mosses on poorly drained sites, and by **lichens** on excessively drained sites.

Does the change induced by canopy opening on the moss/lichen layer affect tree regeneration and/or growth?

## Objectives and methods:

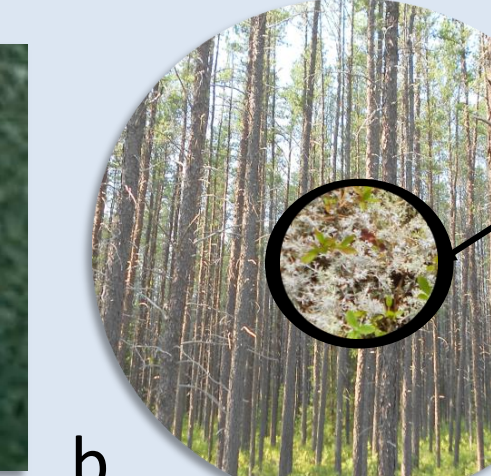
**To determine the relationship:**

- Between the degree of forest canopy openness and the composition of the moss/lichen layer
- Between the composition of the moss/lichen layer, tree root development and nutrient availability in the organic layer.

**Hypotheses:**

- Lichen and Sphagnum moss communities are associated with open forest stands.
- Lichen and Sphagnum mosses are associated with modifications in tree root development and organic soil nutrient availability.

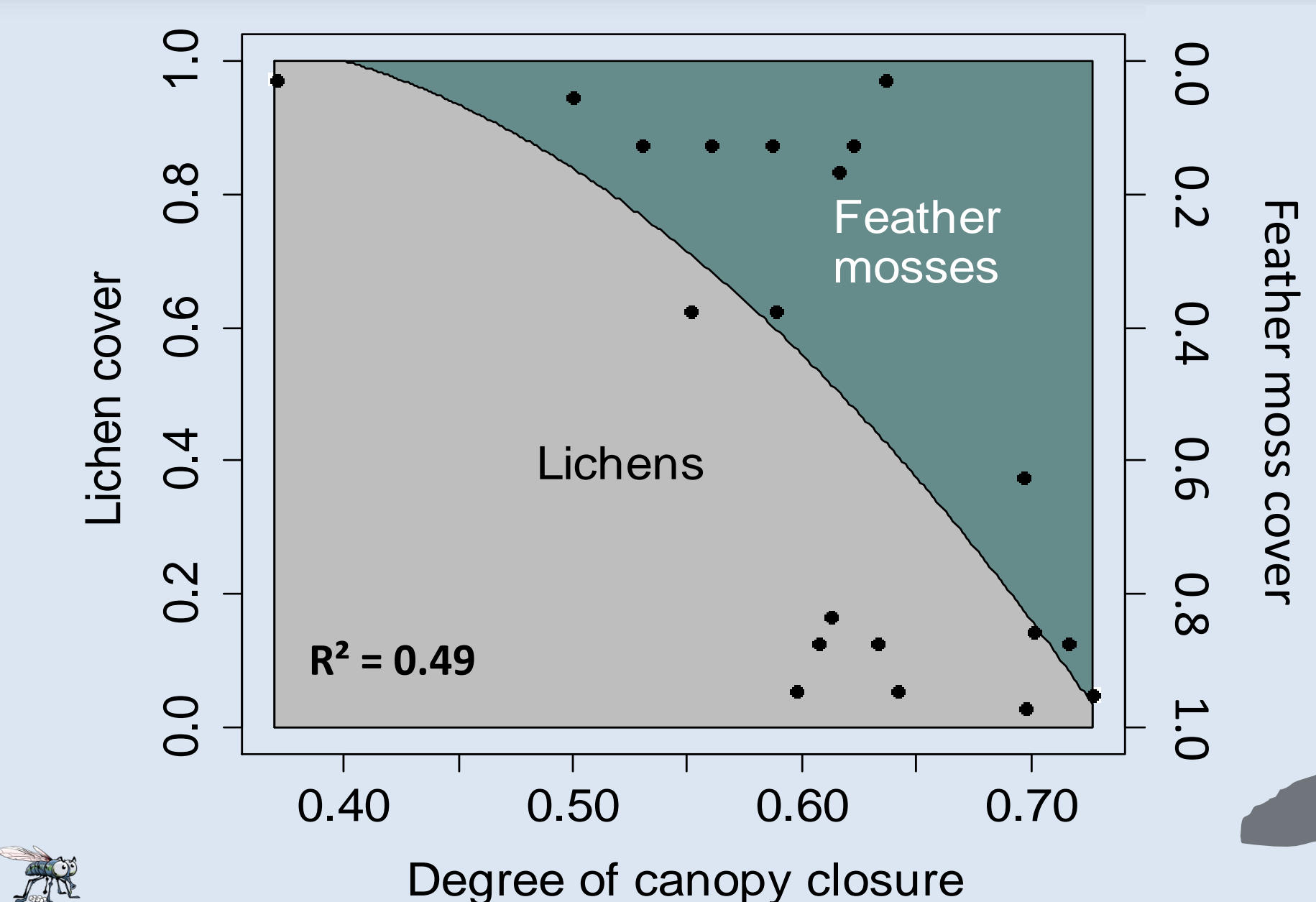
**Method: Sampling in the boreal forest.**



- Vegetation survey
- Fish-eye photos
- Measure of fine root production via root cores (3/plot, 20cm deep)
- Organic soil cores for nutrient analysis (3 cores/plot)

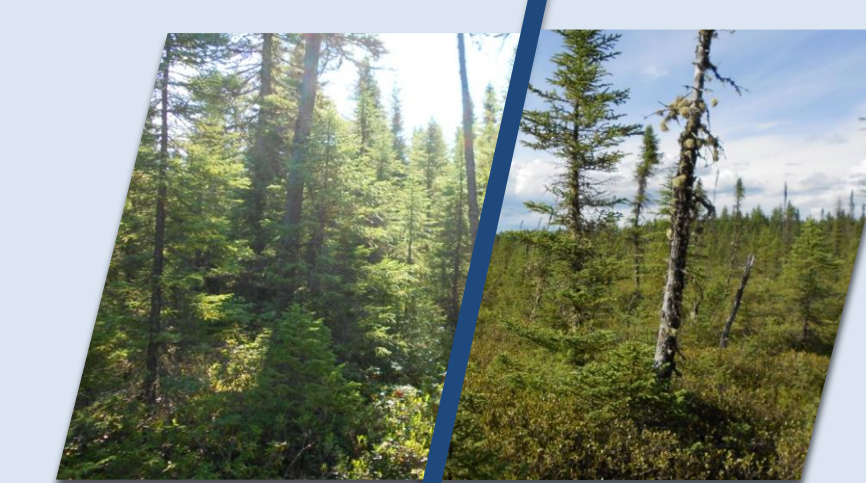
**Sampling design:** a. Distribution of plots along transects crossing different degrees of canopy opening. b. Details of sampling for one plot.

## Results :



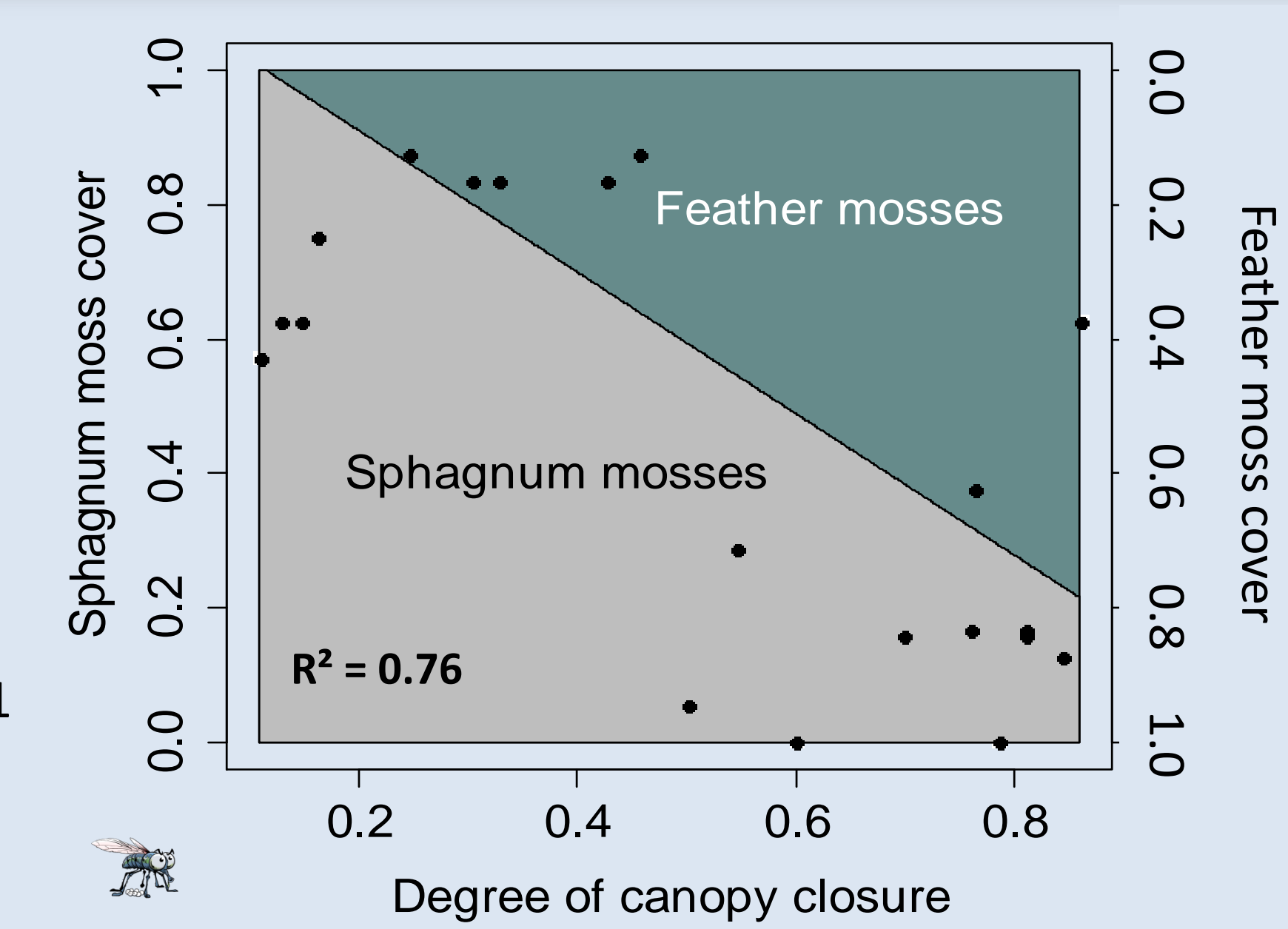
**Lichen cover**

~ Degree of canopy closure  
t-statistics = -3.81; p-value < 0.01

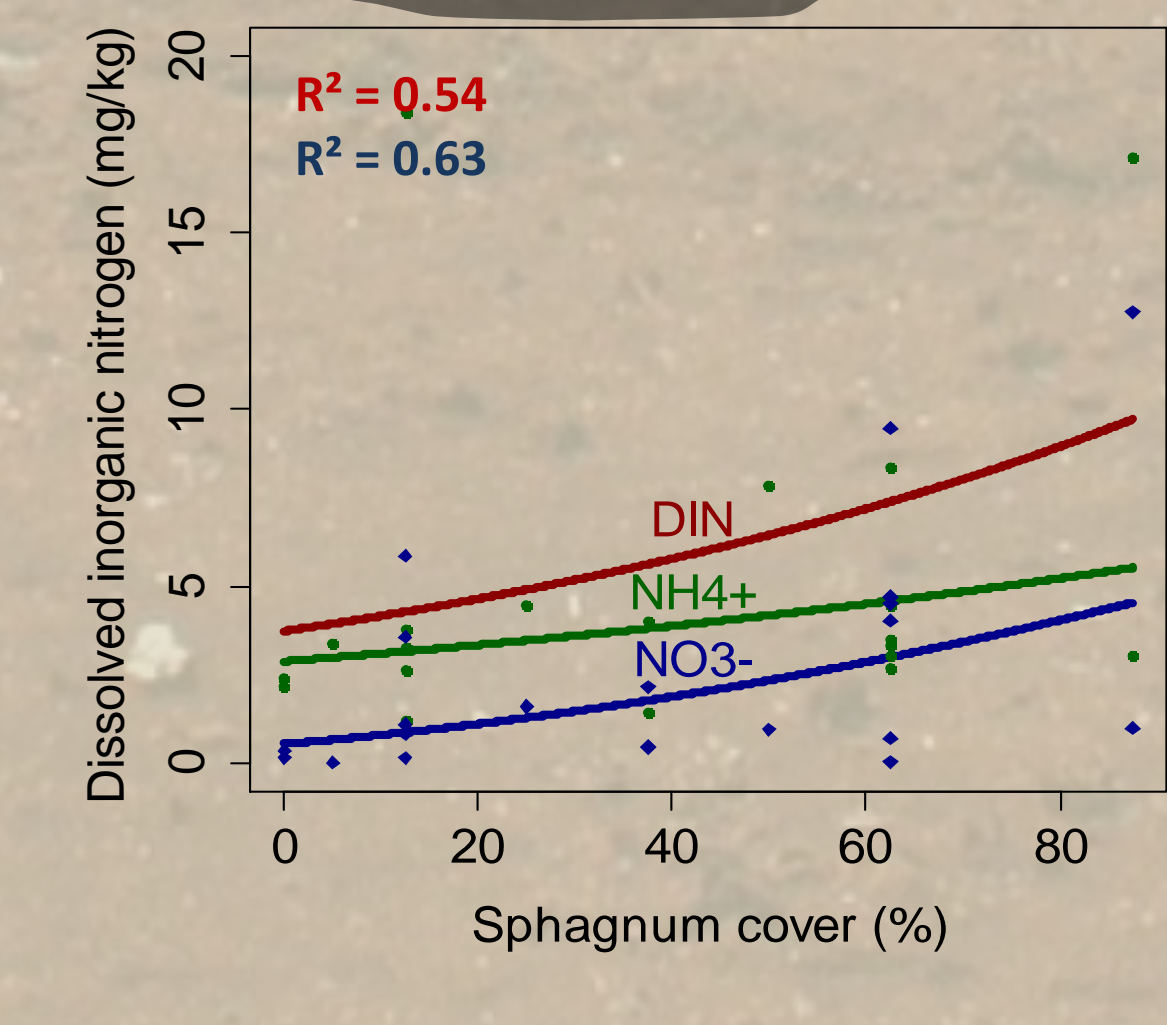
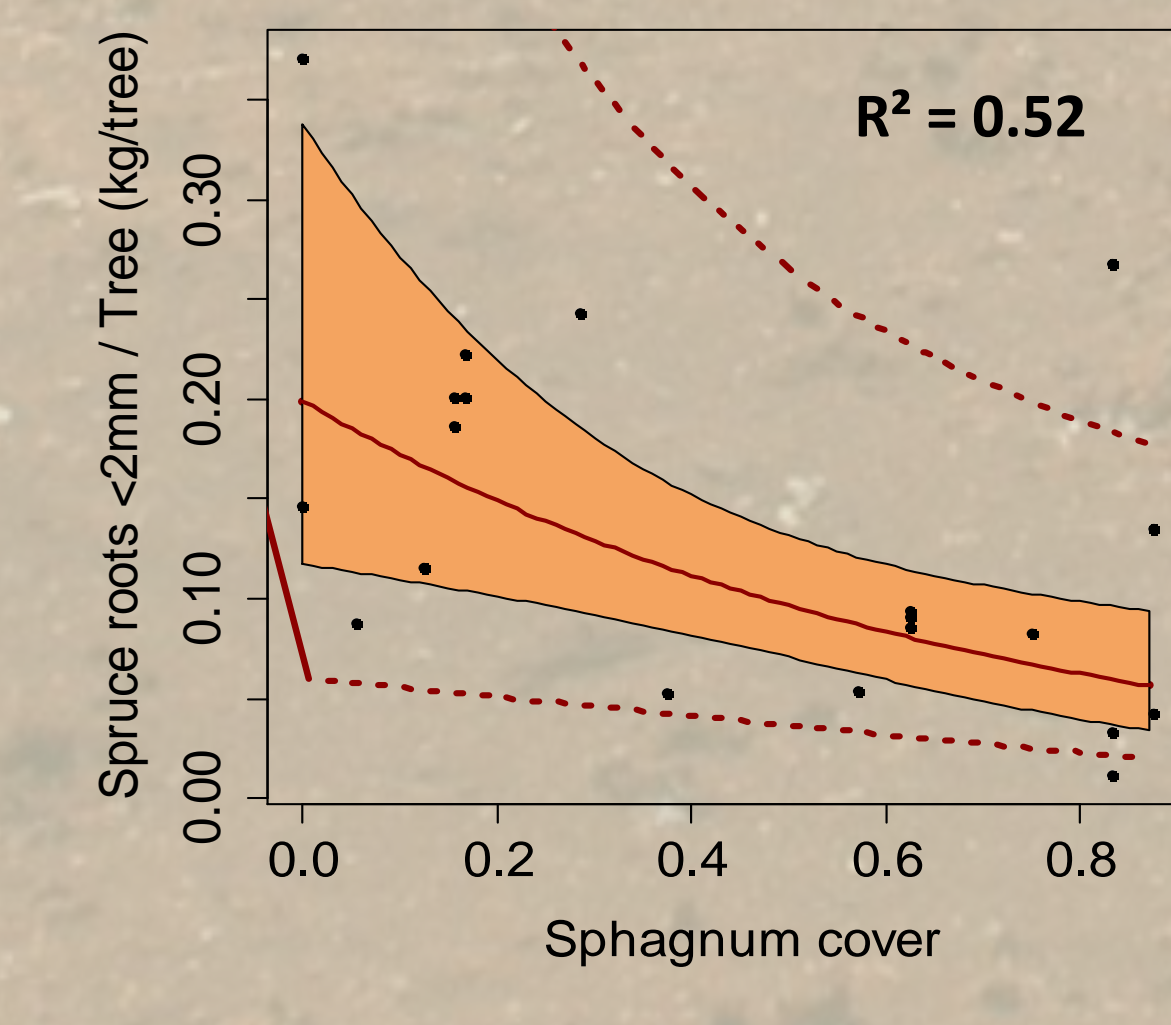
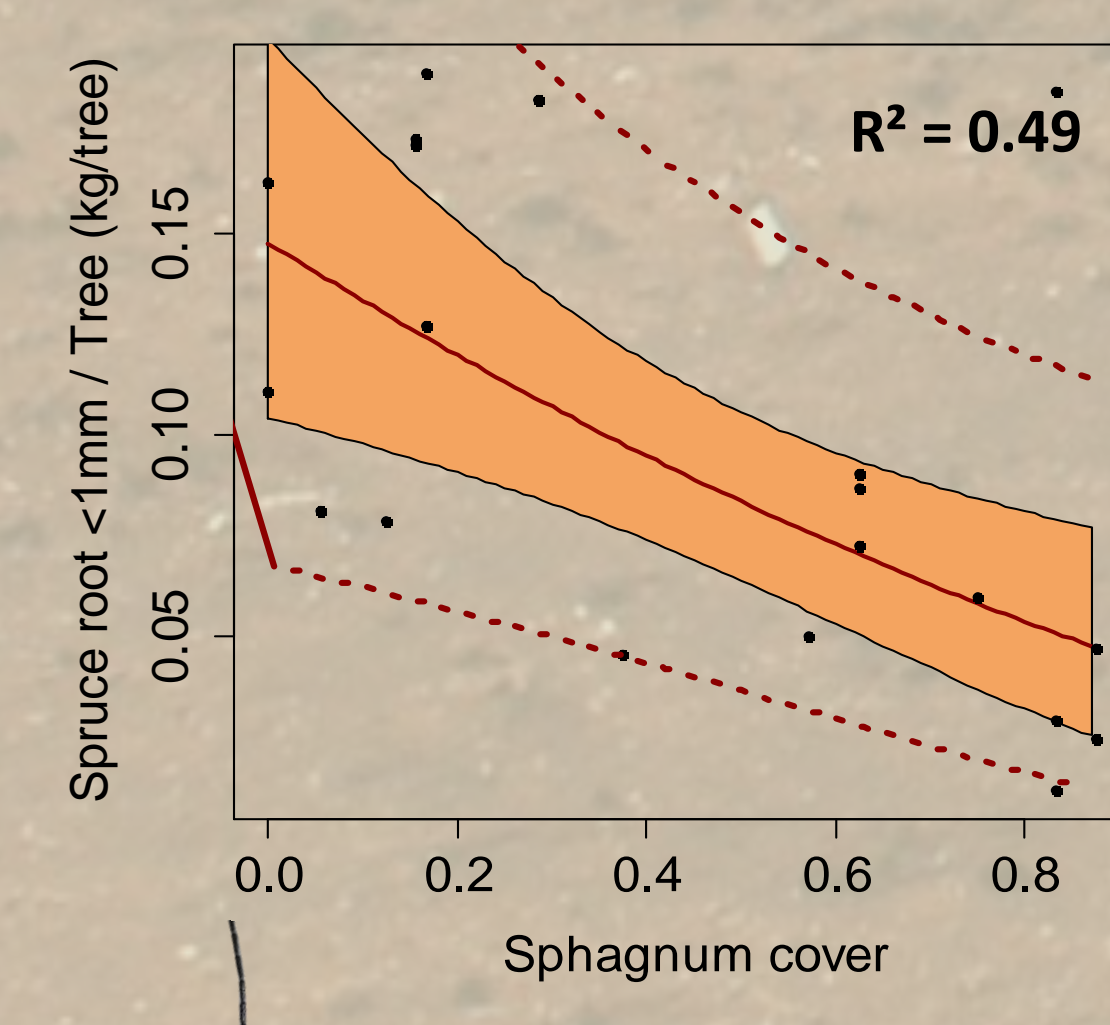
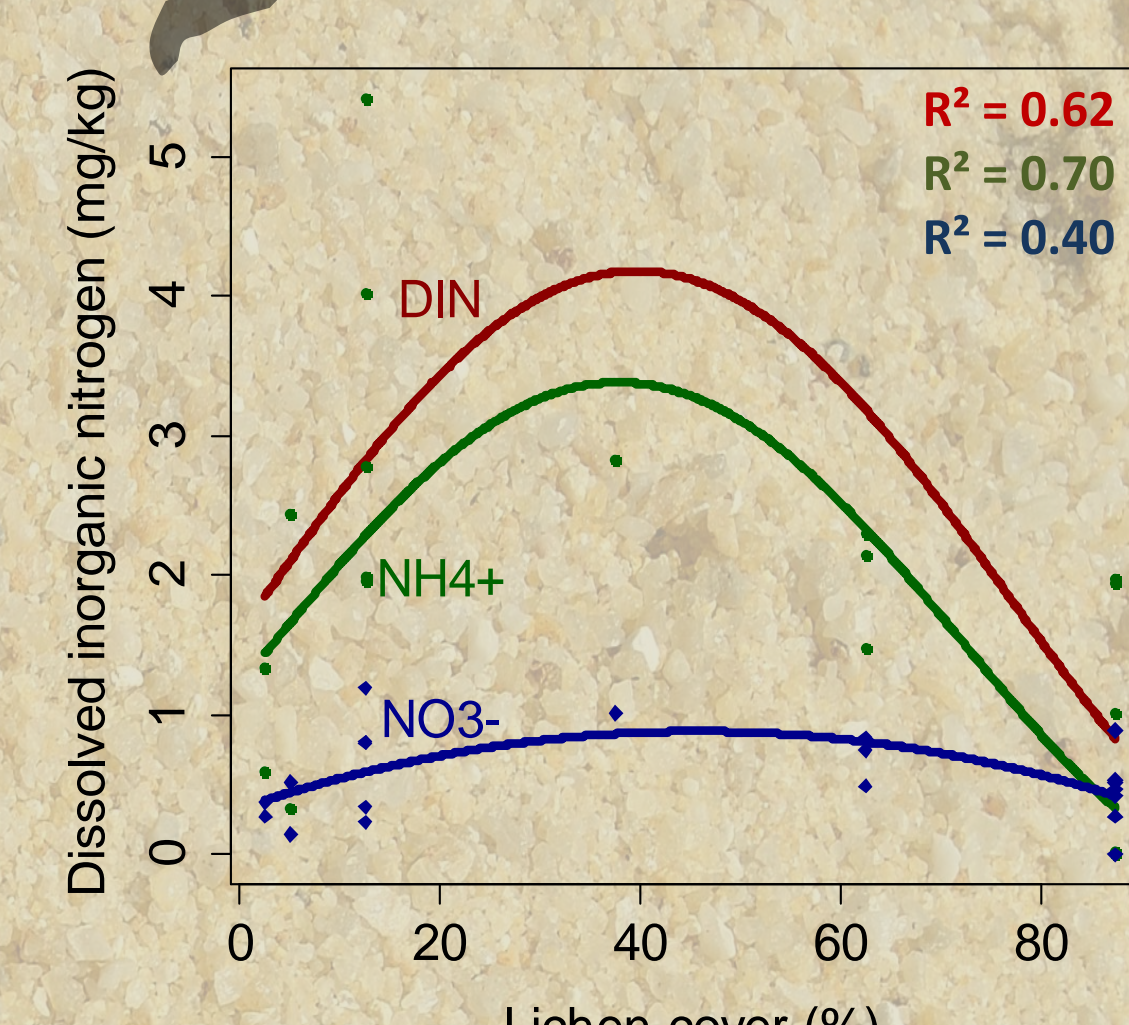
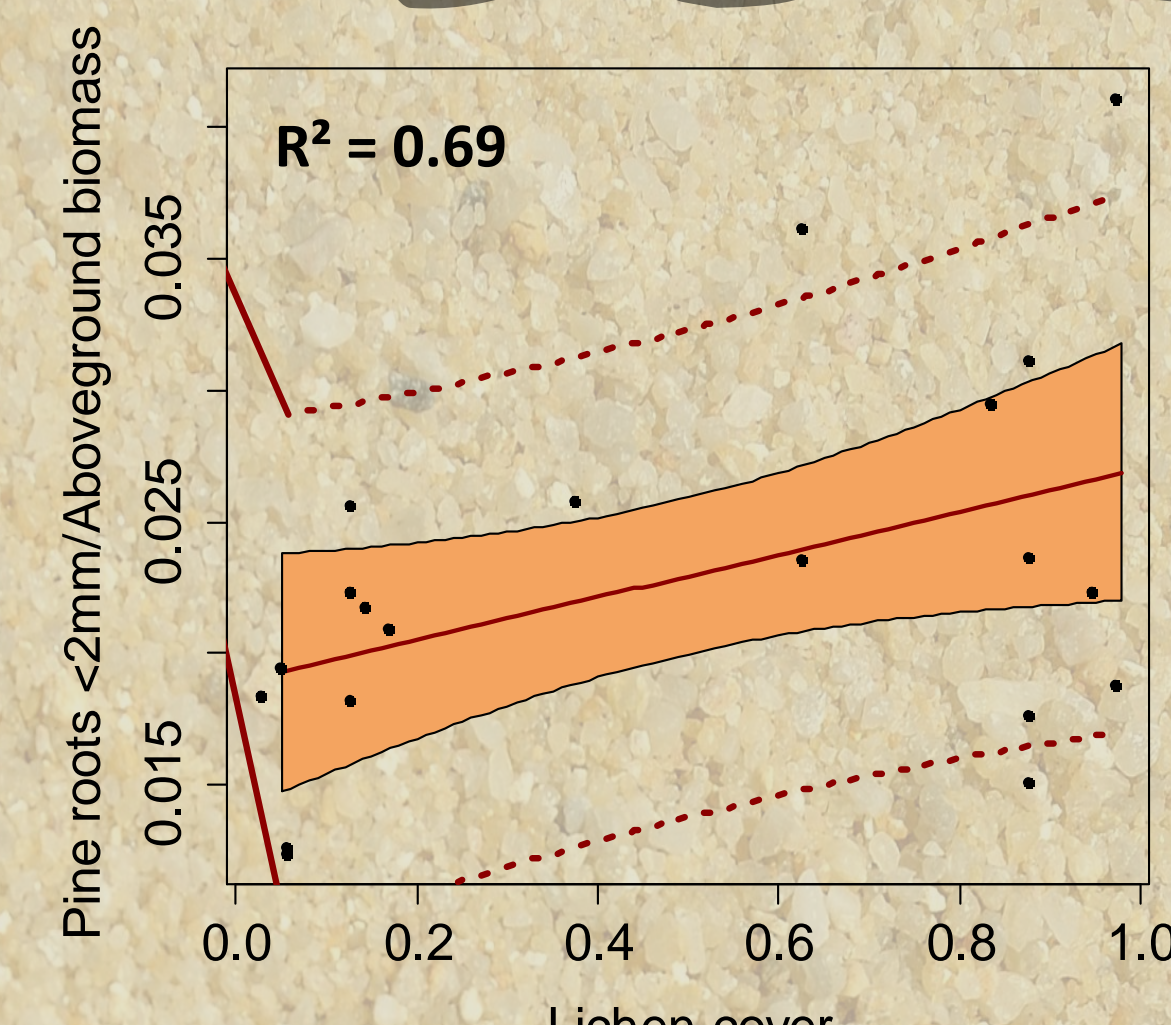
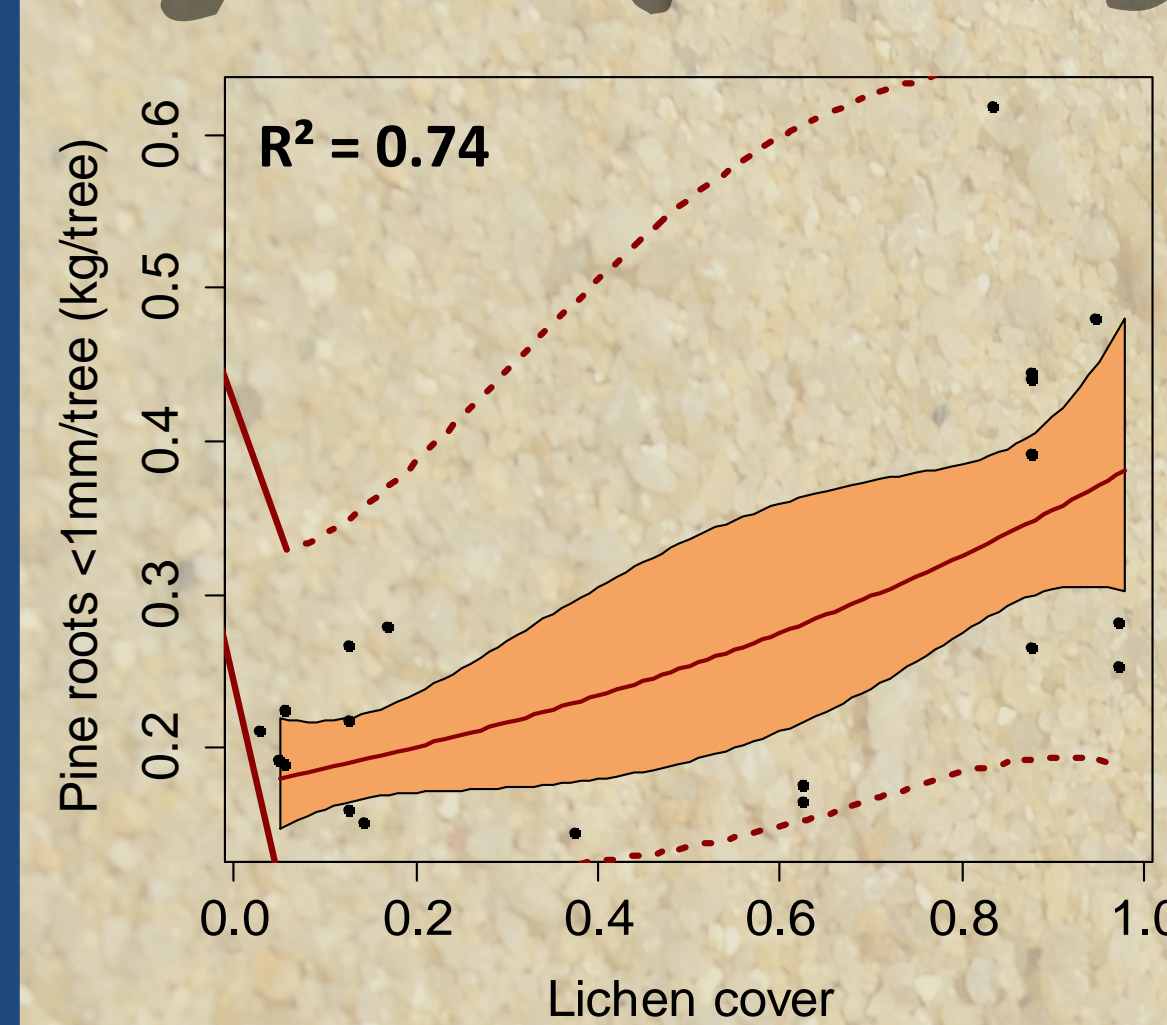


**Sphagnum moss cover**

~ Degree of canopy closure  
t-statistics = -6.49; p-value < 0.001



**Verification of hypothesis 1:**  
Lichen and Sphagnum moss communities are associated with open forest stands.



**Very fine root biomass (< 1mm) per tree and fine root ramification** (proportion of very fine roots < 1mm relative to total fine root biomass < 2mm) **increase significantly with lichen cover** ( $p < 0.001$ ). **Inorganic nitrogen** contained in the organic layer is linked to lichen cover and to very fine root biomass (not represented,  $t = -2.78$ ,  $p < 0.05$ ,  $R^2 = 0.3$ ).

**Verification of hypothesis 2:**  
Lichens are associated with a shift in fine tree root structure and soil nutrient availability.  
Sphagnum mosses are linked to reduced fine root production in trees and a shift in soil nutrient availability.

**Fine and very fine root biomasses per tree (<2mm and <1mm) decrease significantly with Sphagnum moss cover** ( $p < 0.01$ ). **Inorganic nitrogen** concentration in the surface organic layer is greater under Sphagnum mosses than under feather mosses, especially under its nitrate form ( $p < 0.05$ ).

**NB :** Predictions were obtained from mixed models including a random factor linked to the site. **Red solid line:** average prediction considering all sites. **Colored area:** 5% confidence interval. **Dotted red lines:** minimal and maximal limits of the confidence intervals associated with the most extreme sites.

## Conclusions :

**1** Forest stand opening is associated with the installation of lichens and/or Sphagnum mosses at the expense of feather mosses.

The modifications induced by canopy opening on the moss/lichen layer are susceptible to affect tree regeneration and/or growth.

**2** Lichen and Sphagnum mosses are associated with a modification of fine tree root development.

**3** These effects may be linked to the influence of mosses and lichens on nutrient availability in the organic soil.