

The relationship between the defoliation of coniferous trees and environmental factors and weather conditions in Finland

LINDGREN, M.	Vantaa Research Centre, Metla, FIN-01301 Vantaa
HEINONEN, J.	Joensuu Research Centre, Metla, FIN-80101 Joensuu
NEVALAINEN, S.	Joensuu Research Centre, Metla, FIN-80101 Joensuu
SALEMAA, M.	Vantaa Research Centre, Metla, FIN-01301 Vantaa
TAMMINEN, P.	Vantaa Research Centre, Metla, FIN-01301 Vantaa

•Further information about the survey see e.g. Mälkönen, E. (ed.) 2000. *Forest condition in a changing environment -The Finnish case.* Kluwer Academic Publisher, The Netherlands, *Forestry Sciences* 65: 378 p. ISBN 0-7923-6228-4



Objectives

- to study the relationship between ten-year means (1986-1995) of the defoliation degree of Scots pine and Norway spruce and site, stand and environmental factors
- to study the dependence of the annual changes in defoliation degree on the weather conditions (temperature and precipitation)



Network and variables

Based on the level I network

- Only trees (plots) that were assessed throughout the whole observation period were used in the analyses
- Plots with at least three Scots pines (*Pinus sylvestris*) or Norway spruces (*Picea abies*)
- Total of 291 plots (168 plots with pine and 123 plots with spruce)

Crown variables

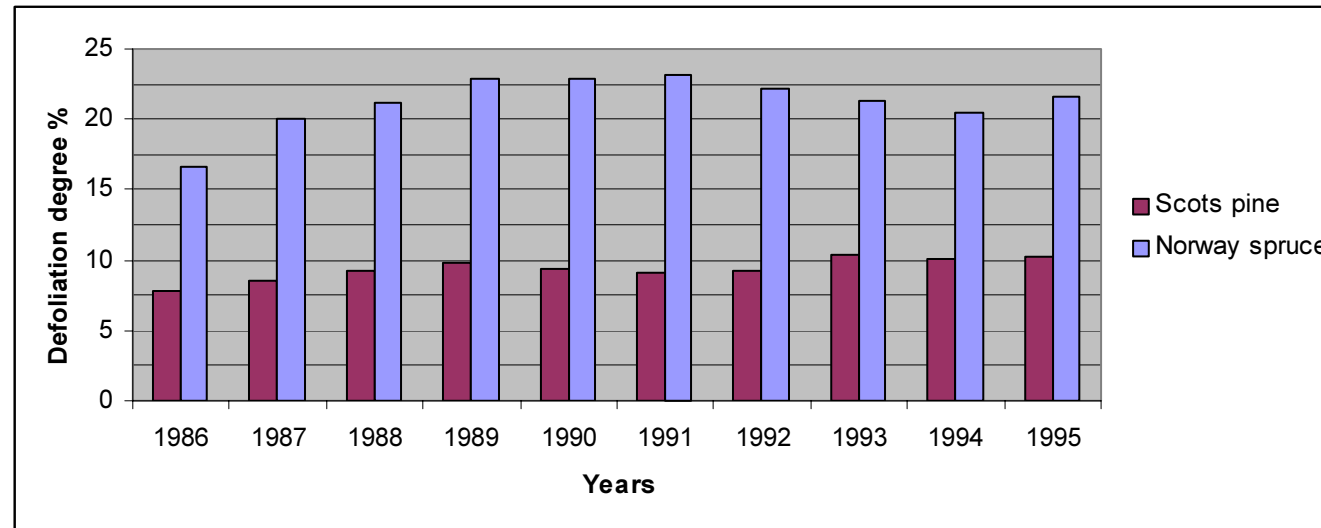
- Plot-specific defoliation degree (annual means) *
- Plot-specific defoliation degree (mean for 1986-1995)**

Explanatory variables

- Climate and weather factors (precipitation and temperature) *
- Stand and site characteristics (e.g. stand age, basal area, site type, altitude) measured in 1990 **
- Soil parameters (e.g nutrient and acidity status), measured once in 1986–1987 (1995) (148 pine plots and 110 spruce plots) **
- The mean sulphate, nitrogen and ammonium deposition values on the sample plots are based on a model applied at the Finnish Meteorological Institute **
- Heavy metal concentrations of mosses for 1990 (291 sample plots) **



Dynamics of defoliation during 1986-1995



- The defoliation degree of pine increased by 2 %-units, and of spruce by 5 %-units during the 10-year period.
- Ageing of the sample trees increased defoliation to some extent. The correlation between the defoliation degree and tree age was positive, and the increase in the defoliation degree due to ageing was estimated to be about half of the total increase during the period.
- The defoliation degree was low in the first year of the period compared with the other years and, after the first year, there was no overall trend in the changes in the defoliation degree.



The dependence of the changes in defoliation degree on the precipitation and temperature during the growing season and preceding growing seasons during 1986–1995

Between-year analysis

- No single weather variable explained more than 1 % of the annual changes in the defoliation degree
- Precipitation in the preceding autumn was the only weather variable that correlated consistently with the change in the defoliation degree of pine.
- None of the weather variables correlated consistently with the change in the defoliation degree of spruce
- In multiple regression analysis with two or more weather variables as regressors, the coefficient of determination was low and the coefficients of the regressors were inconsistent in different parts of the country.

Within-year analysis

- Separate analyses were performed for each year.
- Multiple regression models explained no more than 10 % of the differences between sample plots. Most of the weather variables were significant in one year at least, but the coefficients were inconsistent in different years.
- As for the between-year analysis, the precipitation during the preceding autumn was the most consistent regressor, and explained 4–9 % of the variation in different years.

Defoliation in relation to stand and site factors

- Stand age was the most important factor affecting the degree of defoliation in both Scots pine and Norway spruce. In addition, the greater the diameter at breast height, the higher was the degree of defoliation.
- In the non-standardised data the defoliation degree increased as the effective temperature sum decreased, i.e. from south to north, especially in spruce
- There were no clear differences in the pine defoliation degree with respect to site fertility, but spruces were more defoliated on sites of medium fertility
- Stand age, mean breast height diameter and longitude of sample plot explained over 60 % of the variation in the degree of defoliation on pine.
- The most important explanatory factors for spruce were stand age, mean breast height diameter and site fertility, these variables accounting for 66 % of the defoliation degree. All the other factors explained only a small proportion of the variation, and were not statistically significant
- No statistically significant relationships were found between the mean defoliation degree of conifers and the sulphur or nitrogen deposition or the heavy metal concentration of mosses at the national level.

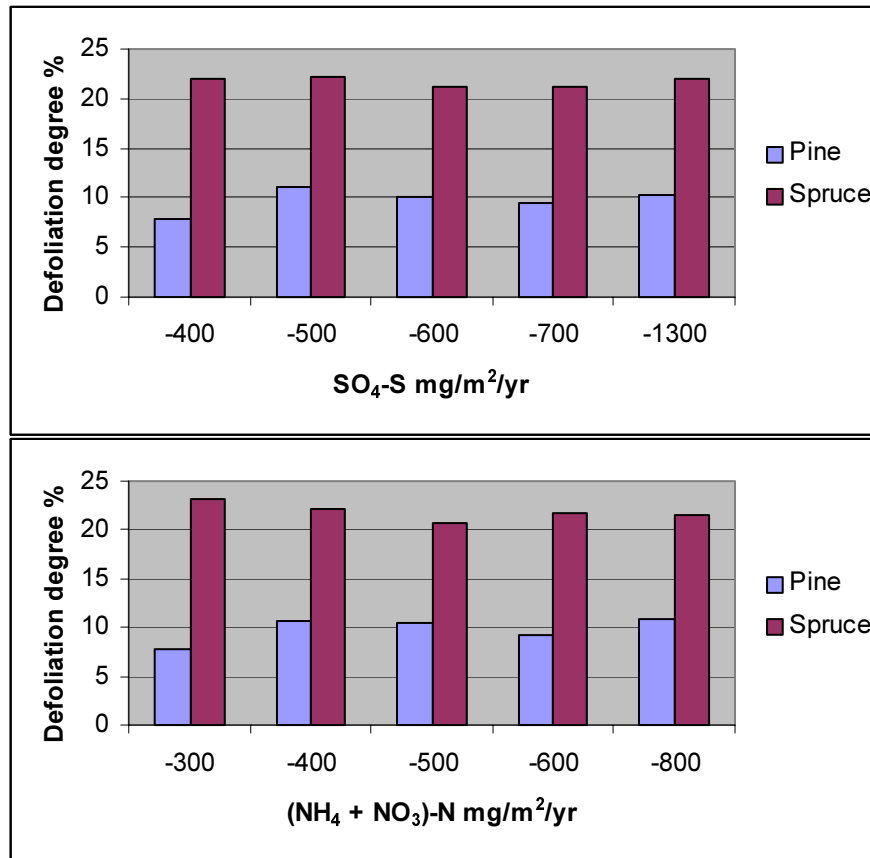


Defoliation in relation to soil properties

- Soil variables explained rather poorly the defoliation variables in the regression models. Stand age and breast-height diameter were also the most important variables explaining defoliation in this material.
- Only one soil variable, the C/N ratio of the organic layer in the Norway spruce stands, was included in the model; the higher the C/N ratio, the higher was the defoliation degree. This means that the defoliation degree of the spruce stands increased as soil fertility decreased.
- Important variables connected to soil acidity, i.e. pH, base saturation and the exchangeable aluminium concentration, did not explain the defoliation degree. Stand ageing is the reason for the correlation between defoliation and the acidity or base saturation of the organic layer in the spruce stands.



Defoliation in relation to air pollution in age-standardised data



- The defoliation degree on Scots pine appeared to be the lowest in those areas where sulphur and total nitrogen were also the lowest. However, the defoliation degree of pine did not increase linearly with increasing deposition levels.
- No relationship was found between the defoliation degree on Norway spruce and the deposition level.



Conclusions

- Stand age increases towards the north, which makes it difficult to isolate the effects of other factors that also vary along a south-north gradient, e.g. deposition, or are dependent on the effective temperature sum.
- No information was available about the concentrations of ozone or other gaseous pollutants on the sample plots.
- The defoliation degree increased during the early years of the survey, but the between-year variation during the 1990's was relatively small. During the monitoring period, the defoliation degree on pine has increased by 2 % and on spruce by 5 %
- The relationship between the weather conditions and the between-year differences in defoliation during the study period was weak and inconsistent
- No significant correlation was found between the defoliation degree and modelled sulphur and nitrogen deposition and measured heavy metal deposition
- Soil acidity parameters did not explain the variation in defoliation degree. However, a relationship was found between the C/N ratio in the organic layer and the defoliation degree; the higher the C/N ratio, the higher was the defoliation degree

