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Developing a paperwood ideotype for Norway spruce

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In an industry-supported research project we aim at responding to the demands of paper industry for sustainable fibre producing systems. Our purpose is to develop a tree model (ideotype) giving a special emphasis on the requirements of modern paper manufacturing processes. In our view, the paperwood ideotype ought to be capable of producing **large quantities of uniform fibres per unit area when grown at densely spaced stands without thinnings and with short rotations**. Thinnings are disfavoured since the profitability of the logging of small-sized trees is low. A short rotation period (estimated 30–40 years) is a necessity because of greater economic net returns and the avoidance of the problems due to root-rot (*Heterobasidium annosum*), a decaying fungus which is a common problem in spruce stands in southern Finland. In the ideotype scenario, the trees are harvested before the rot has emerged or has had time to spread to the stems.

Our main objectives are

1) to determine the factors and conditions that enable efficient and sustainable production of fibres for paper-making industry
2) to evaluate the potential of *Picea abies* f. *pendula,* a rare natural mutant form of Norway spruce, in meeting the various criteria of the paperwood ideotype.

We hypothesise that the genetically narrow-crowned spruce type comes up to the required standards of the paperwood ideotype. If this hypothesis can be empirically corroborated by field test results, this form of spruce can be rapidly developed into a commercial cultivar as most practical difficulties associated with vegetative propagation have already been overcome.

So far, we have...

- harvested a small sample of trees in a 30-year-old mixed stand comprising both normal phenotypes *(Picea abies)* and narrow-crowned mutants *(Picea abies* f. *pendula)*. The study trees represented the both crown types and three subjective classes **(**weak / moderate / strong**)** of inter-tree competition.
- measured a large number of biomass components on each sample tree (fresh weights of needles and branches by whorl and by year)
- commenced chemical analyses of fibre quality and quantity with wood samples from the study trees, and received the first results

In the future, we aim at...

- collecting more data
- evaluating structural and chemical variation in fiber properties of trees with distinct crown types, competitive status and age
- studying the impact of inter-tree competition on the two distinct types of spruce, focusing on traits such as biomass partitioning, wood producing capacity, harvest index and the uniformity of fibre population.
- adjusting the characteristics of the paperwood ideotype and testing the fittingness of the narrow-crowned spruce to this model,

and, provided that the pendula form displays an adequate match to the modelled ideotype,

- formulating guidelines for economically optimal silvicultural management (e.g., stand density, optimal site types, rotation) of fibre production stands established using clonal material of the narrow-crowned spruce
- co-operating with industry to commence a large-scale vegetative propagation project

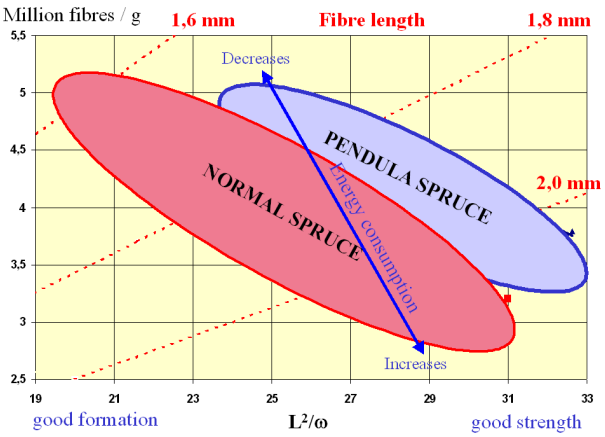

Figure 2. The first results suggest that the fibre populations of narrow-crowned and normal trees differ in some of their characteristics. It seems that pendula spruce might enable slight savings of energy in mechanical pulping. L = fibre length, w = coarseness (mg per metre of fibres).

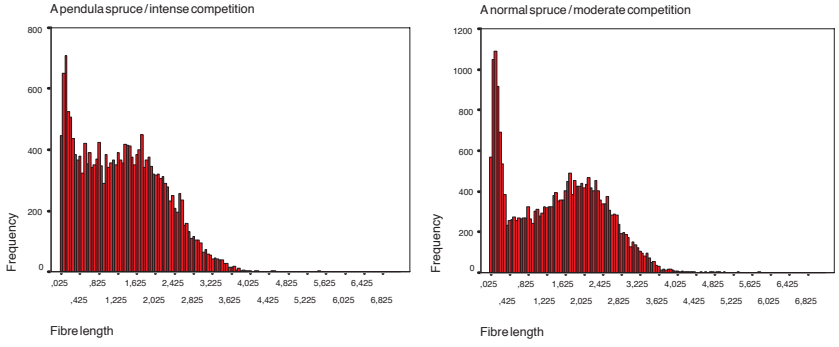

Figure 1. Fibre length distributions of two 30-year-old sample trees, one pendula and one normal spruce, which have been subjected to different intensities of competition.

About the pendulous form of Norway spuce

A small natural stand of some 30 spruce trees with extremely narrow crowns and thin hanging branches was discovered in southern Finland in the 1950's. At that time the trees were about 48 years old. Later studies have suggested that the pendulous crown form in spruce is predominantly controlled by a single dominant gene which is modified by a number of minor genes. In northern areas, the narrow crown is efficient in light interception. The ratio between stem biomass to the total biomass is also generally larger in narrow-crowned spruces compared to the normal type. The high harvest index shown by the pendula spruce is generally considered as one of the most important traits characteristing an ideal crop plant.