The effect of ditch cleaning and complementary ditching on the development of drained Scots pine-dominated peatland forests in Finland

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Summary
The development of drained peatland forests dominated by Scots pine (*Pinus sylvestris* L.) was studied by using data from eight field experiments in which ditch cleaning, complementary ditching, or both were carried out in 1982-1985. Before ditch network maintenance, the mean volume of the stands was 38 m^3ha^{-1}, and 20 years later, 104 m^3ha^{-1}. So far, no commercial cuttings have been done. In Southern Finland, both stand volume and growth were still increasing, and no clear differences between the treatments could be detected after 20 years, including the control plots having been left without ditch network maintenance. In the stands of Northern Finland with lower volumes and growth rates, tree mortality had increased more and the growth rate was lower on the untreated control plots than on the plots that hade been treated by ditch cleaning and/or complementary ditching 20 years earlier.

Key index words: ditch cleaning, Scots pine, volume, yield, mortality

Introduction
When drained for forestry, most pristine Finnish peatlands have had a natural tree stand. Because major part of forest drainage (in all ca 5.5 million hectares) took place between 1960 and 1990, most stands still represent the first post-drainage tree generation. Open ditches with a spacing of 30-60 m and a ditch depth of ca 0.8 m were used. Today, these ditch systems need maintenance: 70-80 000 hectares of peatland forests are annually treated. In operational forestry, the need for ditch network maintenance is determined mainly on the basis of the technical condition of the ditch system, i.e. maintenance is recommended, if the ditches are blocked or deteriorated.

State subsidies (40-65% of the total costs) for the maintenance of forest ditch systems are available to private forest owners provided that 20 years have elapsed since the first drainage. As silvicultural operations have been recommended to be connected with ditch network maintenance (DNM), also first commercial thinnings have often been performed in connection with the first DNM. This may have led to fairly small cutting removals and poor profitability of the thinning operations (see also Kojola *et al.*, 2005).

In the following, the stand development during 20 years after ditch network maintenance is examined by using data from eight Scots pine-dominated sites. The main idea is to demonstrate what happens, if early cuttings and ditch network maintenance are performed later than is typical of the current practice.

Materials and methods
Twelve field experiments including different treatments of ditch network maintenance were established in 1982-1985 (Päivänen and Ahti, 1988; Ahti and Päivänen, 1997; Fig. 1). Here, two of the twelve experiments were rejected because they do not include all four treatments, one because of a commercial cutting and one because it is naturally understocked. The remaining eight experiments used in this treatise include 24 control plots representing the original (non-maintained) ditching, 30 ditch cleaning plots, 29 complementary ditching plots, and 28 plots with the combined treatment (ditch cleaning + complementary ditching).

The stand characteristics were determined at the time of establishment and every five years after it, five times in all. All trees were numbered. The breast height diameter of all trees was measured in each plot. Simultaneously, about thirty sample trees in each plot were selected to represent the stem diameter distribution. From the sample trees, height, stem diameter at the height of six metres and height increment during the five last years were determined. Standard stand properties such as the stand volume of the growing stock were then calculated from the data and 5-year volume growth was determined as the difference between the volumes of two subsequent measurements.

The stand characteristics are presented as arithmetic treatment means of three experiments in Southern Finland and five experiments in Northern Finland.

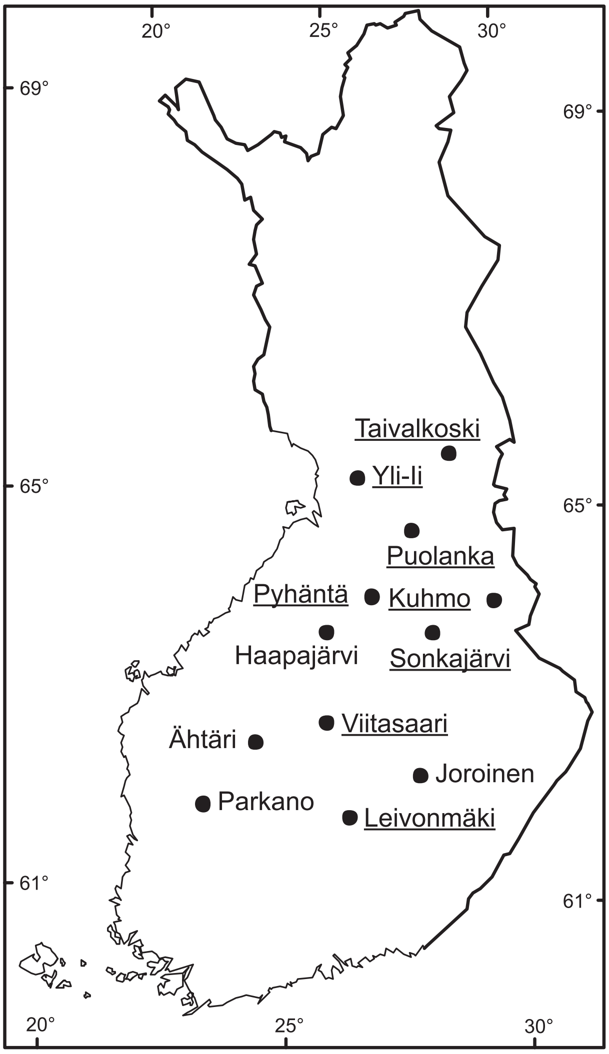

Figure 1. Location of the experiments. The sites included in this paper are underlined.

Results

In the southern experiments, mean stand volume increased from 60 to 160 m³ha⁻¹ during the 20year period, and this occurred irrespective of the treatments including control, even if the wet-period water tables was initially lowered by 5-10 cm by DNM (Ahti and Päivänen, 1997). In the northern experiments, the increase in stand volume was from 25-30 to 80-90 m³ha⁻¹ except for the control plots where the increase was smaller, from 25 to less than 70 m³ha⁻¹ (Fig. 2). Correspondingly, the effect of DNM on five-year yields was small in Southern Finland, whereas a clear effect could be detected in Northern Finland (Fig. 3). Tree mortality has clearly increased during the last 5-year period in Southern Finland, but seems to have been more or less independent of treatment. It appears to be connected with the stand volumes increasing up to 130-160 m³ha⁻¹ when also increased inter-tree competition is expected (see also Kojola *et al.*, 2005). In Northern Finland, where the natural removal has been distinctively lower than in Southern Finland, mortality has also increased during the last 5-year period, but here it appears to have been induced by lacking ditch network maintenance (Fig. 4).

Discussion

In a previous paper dealing with the same series of experiments (Lauhanen and Ahti, 2001), slight but statistically significant increases in growth were reported for the first 10 years after ditch network maintenance. In Southern Finland, the slight changes in tree growth have not much influenced stand development even during the following 10-year period. This is probably due to the increased evapotranspiration from the stands themselves, as indirectly shown by Ahti and Hökkä (2006). If the tree stand is large enough, its interception and transpiration might compensate for the deterioration of the ditch network. The ditch system might be shallower than before, but is still capable of conducting that part of runoff which enters the ditches on soil surface or through the topmost peat layers, and together, the shallow ditches and the large tree stand obviously can keep the ground water level as deep as the smaller stand and the deep ditches did earlier.

It appears that the uneven-sized first tree generation of Scots pine becomes largely independent of the condition of the ditches, especially ditch depth, as stand volume exceeds 100 m³ha, and consequently, the ditch network does not need to be repaired. Second, if only annual yield and removal are regarded, and the silvicultural quality of the stand is not taken in consideration, there seems to be no

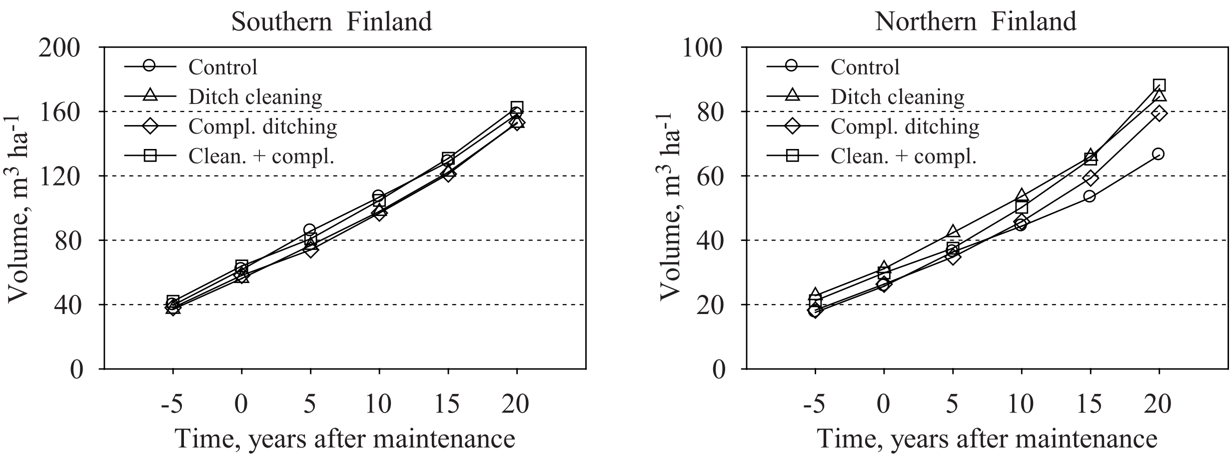

Figure 2. The development of stand volume as influenced by ditch cleaning and complementary ditching. The pre-treatment volumes (-5) were estimated on the basis of coring 20 trees per plot at $d_{1.3}$.

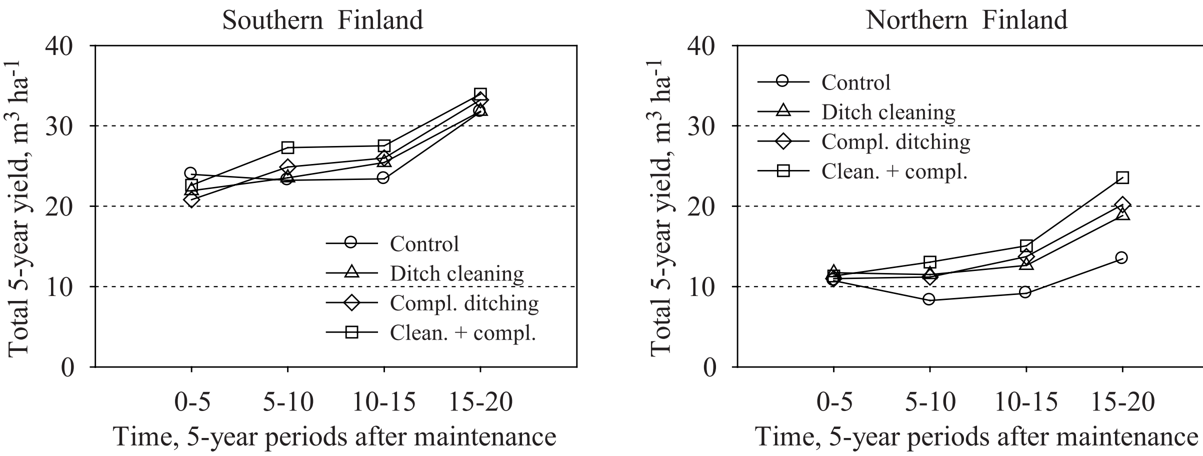

Figure 3. Mean growth of the stands during four 5-year periods after ditch cleaning and complementary ditching.

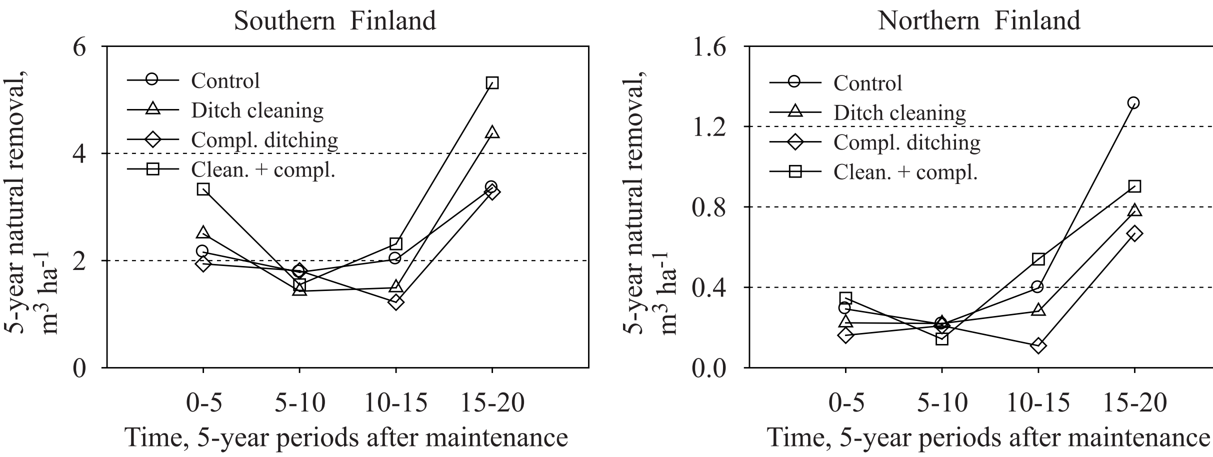

Figure 4. Mean natural removal in the stands during four 5-year periods after ditch cleaning and complementary ditching.

urgent need for commercial cuttings in first-generation Scots pine-dominated peatland forests before stand volume exceeds 150 m^3ha^{-1}. The results presented here suggest that also the further development of a Scots pine stand may remain largely independent of the condition of the ditch system, if the volume of the stand is not reduced below 100 m^3ha^{-1} by commercial cuttings or other reasons. Whether this holds also for peatland stands in the more humid climate of Northern Finland, can not yet be answered on the basis of the present data.

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