MACROPHYTE SUCCESSION IN SWEDISH LAKES
 CAUSED BY DEPOSITION OF AIRBORNE
 ACID SUBSTANCES

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Abstract. Recurrent biological investigations have been made in six lakes in two areas in western Sweden. It has been found that the supply of acid substances induces long-term biological perturbations at all trophic levels in the lake ecosystem. Among these changes, the \textit{Sphagnum} expansion is believed to strongly affect the dynamics in the lake. A quantification of the \textit{Sphagnum} expansion in different depth zones of a lake was made. The rate of this invasion was found to be highest in shaded and sheltered areas of the littoral. The abundance of \textit{Sphagnum} mats is furthermore negatively correlated to the pH of the lake water.

The further consequences for the lake ecosystem of this occupation of ever-larger bottom areas by dense \textit{Sphagnum} mats are discussed.

1. Introduction

In 1968, Odén presented results of studies which clearly pointed to an increasing acidity in precipitation and in a number of rivers in Sweden. He also discussed the long-term consequences of this acidification for our soil and water resources (Odén, 1968). The large number of reports on this subject published since then, particularly in Sweden, Norway, and Canada, have justified the misgivings previously expressed by Odén (Henriksen, 1972; Jensen and Snekvik, 1972; Almer \textit{et al.}, 1974; Beamish, 1974; Grahn \textit{et al.}, 1974). Consequently, in Scandinavia today a large number of lakes and running waters are suffering irreversible biological damage, with total fish kill in some areas, as a result of increasingly acid water (Hultberg and Stensen, 1970; Jensen and Snekvik, 1972).

For several years now, the effects on lake ecosystems of the increasing acidification have been studied within the framework of a current research project at the Swedish Water and Air Pollution Research Laboratory (Grahn \textit{et al.}, 1974).

The study comprises six small lakes (16 to 78 ha), three in the province of Bohuslän just north of Gothenburg on the Swedish west coast, and three in the province of Värmland, 300 km further north (Figure 1). All the lakes except for one are clear-water lakes, situated high above sea level and surrounded by moraine ground. There are no industrial or populated areas in the surroundings, and thus no direct discharges of pollutants into the lakes.

The investigations so far have shown that disturbances occur on all trophic levels: among fish, macrophytes, bottom fauna, plankton as well as among micro-organisms. Of these ecological changes, the macrophyte succession, in particular that of \textit{Sphagnum}, is one that may strongly affect the dynamics in the lake.

No distinction was made in this study between the different \textit{Sphagnum} species.

Unless otherwise stated here, \textit{‘Sphagnum’} therefore refers to all \textit{Sphagnum} species observed in this investigation.
2. Chemical Data

In both investigated lake areas, sulphur and nitrate in precipitation have increased, and the pH in precipitation decreased by more than one pH-unit since 1955 in Värmland and 1958 in Bohuslän (Figures 2a and b).

In Bohuslän, pH in the lake water has fallen 1.4 to 1.6 units since 1948, and a drop of the same order has occurred in Värmland since 1937–39. No pH-measurements