SCHOENUS VEGETATION AND ENVIRONMENTAL CONDITIONS IN SOUTH AND SOUTHEAST SWEDEN*

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Introduction

In an earlier study the regional discontinuities within the vegetation of Schoenus-dominated wetland areas in South and Southeastern Sweden were described (Tyler 1980). By numerical methods two associations were distinguished, the Primula-Schoenus ferrugineus association, mainly occurring in the provinces of Skåne, Öland, Östergötland and Gotland, and the Oxycoccus-Schoenus ferrugineus association of the province of Uppland. The Primula-Schoenus association was further divided into eight phytocoena, which were again arranged in three groups, and the Oxycoccus-Schoenus association into five phytocoena. Another five phytocoena, four of them characterized by Schoenus nigricans, were distinguished. In this study the vegetation is regarded in relation to a continuum of species, the abundances of which are related to environmental factors by functions which are non-linear, often also non-monotonic and with zero values over part of the range (Noy-Meir & Whittaker 1977:82).

The first objective is to establish if the observed variation in the vegetation is related to the variation in any of the investigated environmental variables, and to study the relative importance and interactions of these variables. The second objective is to characterize each phytocoenon, distinguished in Tyler (op. cit.) by environmental conditions.

In Sweden, Witting (1947, 1948), Du Rietz (1949, 1954, 1959), Malmer & Sjörs (1955), Sjörs (1959, 1961) and Malmer (1962a), have studied environmental variables which are considered to be of importance for the differentiation of the plant cover in the vegetational gradient 'poor – rich' (e.g. Du Rietz 1949, Sjörs 1971, Trass & Malmer 1973). These variables include pH, calcium content and content of other mineral nutrients. Witting (op. cit.) and Du Rietz (1954) considered the calcium concentration to be the most important environmental variable for the variation: bog – poor fen – rich fen – extremely rich fen vegetation. According to Sjörs (1952), the acid-base state is the main environmental gradient along which the vegetation of bog – poor fen – rich fen is distributed. He also stated that a 'high content of salts (at least of calcium bicarbonate) in the mire water is generally combined with rich fen vegetation but the latter is not always dependent on the former'. Calcium is considered to explain the composition of the vegetation to a large extent (Sjörs 1971). The influence of other environmental factors (e.g. water movements) was stressed by Gorham (1952) and Malmer (1962b, 1965) and also the importance of the amount per unit of time rather than instantaneous concentrations. Gorham concluded that the best method for studying mire vegetation in relation to environmental conditions is that of Tuomikoski (1942), i.e. the directions of variation, a method used by several Swedish mire (bog and fen) investigators (e.g. Sjörs 1948, 1950, Malmer 1962). An attempt to discriminate between bog – fen – marsh – swamp with regard to nutrients has also been made by Stanek et al. (1977), who concluded that Ca, P and N are best suited as discriminators. Fen and marsh
were well separated from bog and swamp, but it was not possible to separate fen and marsh by soil chemical properties. Extremely rich fens, to which the *Schoenus* wetlands (sensu Tyler 1980) belong, according to Waldheim & Weimark (1943) and Du Rietz (1949), have a high pH (> 6.0 in soil water, Witting 1947, 1948; > 7.1 Sjörs 1952, Malmer 1965), a high concentration of calcium in soil water (> 37 mg/litre, Du Rietz 1954), and a high CEC (cation exchange capacity), base saturation and total concentration of N and P in comparison to moderately rich fens (Sjörs 1961).

Values of pH stated in the literature for *Schoenus* vegetation from outside Sweden vary between 5.3 and 8.5 (mostly measured in water suspensions). Calcium carbonate content varies between 0.5 and 90 percent of dry soil matter (e.g. Zobrist 1935, Trass 1957, Langer 1958, Eicke-Jenne 1960, and Kask 1965). Few authors have studied CEC, organic carbon or humus content, or available phosphate (e.g. Boeker 1957) Aluminium ions, $\text{Al}^{3+}$, in very low concentrations are toxic to *Schoenus nigricans* and *Carex lepidocharpa* from the British Isles (Clymo 1962, Sparling 1967). This may be the reason why they are restricted to sites with a high pH ('rich fens') or a low natural $\text{Al}^{3+}$ concentration (bogs). *Carex lepidocharpa* also seems to require high concentrations of calcium ions. However, it is not known whether these findings are applicable to Swedish conditions.

Nowadays, directions of variation are often studied by ordination techniques, i.e. indirect gradient analysis, though the non-linear species response to the influence of environmental variables makes a careful study of these relationships necessary (Austin & Noy-Meir 1971). The interpretation of the principal axes of the species-dimensional space as corresponding to axes of an environmental space (cf. Beals 1973), may be replaced by an ordination of the environmental variables alone or in combination with the species as an approximation, at least, of the vegetational space (Beals op. cit.), an ecosystemic ordination in the sense of Jeglum et al. (1971). Such a space is difficult to define because the environmental variables are not independent, and their effects on species synergetic. The variables are accordingly difficult to define, also as main factor complexes, and also difficult to measure in a manner corresponding to their influence on species. Owing to different scales of the environmental variables, their ordination requires standardization, the effect of which is thoroughly discussed by Noy-Meir et al. (1975). Only rather few authors have used ordination techniques on environmental variables (Ferrari et al. 1957, Bunce 1968, Goldsmith 1973, Bouxin 1975, 1976, and Gauch et al. 1976) or on the combination of species and environmental variables (Gittins 1969, Walker & Wehrhahn 1971). Although Gauch et al. (op. cit.) are of the opposite opinion, Robertson (1978) says that, of several ordination techniques, reciprocal averaging gives the ordination of stands and species which is least difficult to interpret in relation to environmental variables.

**Methods**

**Field and laboratory methods**

Investigation area and vegetational data have been presented (Tyler 1980). Soil sampling was performed in most standard areas (size 4 m$^2$, here called stands), used for vegetation sampling. After removal of the moss-layer in the interspaces, soil samples, representing the 0–10 cm level, were collected. Sometimes the ground was too stony to allow any sampling. Height of tussocks and thickness of the soil mixed with organic matter (in the following text called 'peat') were always estimated, the latter with a 2-m probe. The samples were frozen as soon as possible, and thawed immediately prior to analysis. pH was measured electrometrically directly in the fresh soil sample, if this consisted mainly of organic matter, or in a water suspension of fresh mineral soil (weight prop. 2:1) in the case of all samples from Öland and Gotland and a few from Östergötland. After removal of stones and living roots water content and dry (105 °C) weight were estimated. From the fresh sample, the cations were extracted by leaching with neutral, molar NH$_4$ OCOCH$_3$, and phosphate by 0.5 M NaHCO$_3$ (pH 8.5). Metal elements were determined by atomic absorption spectrophotometry (Ca, Mg, Fe, Mn) and flame photometry (Na, K) and phosphate by spectrophotometry using the ascorbic acid method according to Alexander & Robertson (1970). Organic carbon was determined by the method of Tyurin (Kononova 1966), nitrogen by a semi-micro Kjeldahl procedure and carbonate titrimetrically according to Bundy & Bremner (1972). Finally, chloride ions were determined titrimetrically (Jackson 1958) in water extracts of a few samples.

Values of pH, estimated in water suspensions of carbonate rich soils, are considered minimum values, because percolation of CO$_2$ saturated water through soil (in situ) displaces the CO$_3^{2-}$ – HCO$_3^-$ equilibrium, especially important in rainy periods (Turner 1959). Seasonal