ABSTRACT: The relationships between community structure and soil properties (pH, P, N, Ca, Mg, CaCO₃, and clay content) were examined in a swamp forest from the northern part of Turkey. Statistically significant correlations were found between the soil variables and three different associations (Fraxino excelsioris-Fraxinetum angustifoliae, Carpino orientalis-Pterocaryetum fraxinifoliae, Acero campestris-Alnetum glutinosae) according to CCA ordination. P, Mg, Ca, and clay content of soil were found as four significant variables for species composition in the studied forest.

KEYWORDS: swamp forests, vegetation-environment relationships, species diversity

RELATIONSHIPS BETWEEN COMMUNITY STRUCTURE AND SOIL PROPERTIES OF A SWAMP FOREST FROM NORTHERN TURKEY

The study area is a swamp forest which covers an approximately 86 ha; it is situated in the Central Black Sea Region at sea level, Northern Turkey (41°18’N; 36°55’E). Climatic and soil properties of the study area are given in Kutbay (2001). The cover values of all vascular species were estimated in each vegetation layer (tree, shrub and herb layers) according to Braun-Blanquet cover-abundance scale (Mueller-Dombois and Ellenberg 1974). The size of quadrats were estimated by means of minimal-area method. Ten floristically and structurally homogenous plots were taken, (average area of 700 m²), which represent the main vegetation types. Ten soil samples were taken from these plots simultaneously; they represent the ecological site ranges for the study area (Kutbay 2001). Soil samples were taken in each plot at a depth between 0 and 30 cm during mid-growing season (August 1994). Soil texture and the other parameters like pH, nitrogen, phosphorus, potassium, magnesium, and CaCO₃ (%) content were determined by standard methods (Allen et al. 1986). The data set was classified by TWINSPLAN procedure. Cover data of spe-
cies were analysed according to the Braun-Blanquet scale as proposed by van der Maarel (1979). Division and Eigenvalue were calculated according to Hill (1979). To detect gradients in species composition and in species-environment relations, canonical correspondence analysis (CCA) was performed by using the CAP 1.5 version (Community Analysis Package, 1999) and ECOM 1.33 version (Environmental Community Analysis, 2001) software programmes. Canonical Correspondence Analysis (CCA) was proposed to constrain the axes in classical Correspondence Analysis (CA) to be linear functions of a priori defined or measured variables associated with species records (relevés). The ordination axes of CA are termed Eigenvectors. Each Eigenvector has a corresponding Eigenvalue, often denoted by $\lambda$. The Eigenvalue is actually equal to the (maximized) dispersion of the species scores on the ordination axis, and is thus a measure of importance of the ordination axis. The first ordination axis has the largest Eigenvalue ($\lambda_1$), the second axis is the second largest Eigenvalue ($\lambda_2$), and so on. The Eigenvalues of CA all lie between 0 and 1. Values over 0.5 often denote a good separation of the species along axis (Jongman et al. 1995).

Species diversity was calculated as the Shannon-Wiener index:

$$H' = \sum_{i=1}^{S} P_i \log_2 P_i$$  (1)

where $S$ is the total number of species and $P_i$ is the relative cover of $i$'th species. Evenness (Russell et al. 1985) was calculated as:

$$J = \frac{H'}{H_{max}}$$  (2)

where $H_{max} = \sum_{i=1}^{S} \log_2 P_i$  (3)

According to the results of TWINSPAN clustering it was found that there were three associations (Fraxino excelsioris-Fraxinetum angustifoliae, Carpino orientalis-Pterocaryetum fraxinifoliae, Acero campestris-Alnetum glutinosae) in the studied swamp forest (Fig. 1). Many of the species in the associations belong to Querco-Fagetea class which represents the climax character of the studied forest. Investigations on vegetation succession based on detailed peat corings prove that the natural succession under meso-eutrophic conditions from Po-tametea and Phragmitetea may gradually lead to Alnetea forests (directly or via sequences, frequently accompanied with initial shrub stages with Salix aurita and S. cinerea (Prieditsis 1997 b).

As shown in CCA ordination (Fig. 2) high values of P, Ca and Mg concentration are the most significant soil parameters for Acero campestris-Alnetum glutinosae. High values of N and CaCO$_3$ concentration and clay content are associated with occurrence of Fraxino excelsioris-Fraxinetum angustifoliae. High value of pH is associated only with the occurrence of Carpino orientalis-Pterocaryetum fraxinifoliae.

The study area occurred at sea level and P, Mg, Ca and clay content of soil were found as four significant variables affecting species composition in the studied forest (Fig. 2). However, pH was not found as a significant variable. Our results supported the results of Hseu and Chen (2000) who found that P, Mg, Ca and clay content of soil affect the species composition of swamp forest. However, our results failed to support the results of Økland and Eilersten (1993) who found that pH is a single environmental parameter that explains the variation along a poor-rich coenocline. Goldberg (1982) stated that calcium, in particular, plays an important role in “maintaining the integrity of the absorption and selectivity mechanisms involved in uptake of cations general” and calcium is a good indicator of forest soil fertility. Thus, low availability of calcium may further decrease availability of other nutrients. Goldberg (1982) also found P content of soil positively correlated with clay content.

The cumulative percentage of variance accounted by the first two axes is equal to 19% of the species composition and 33% of the species-environment relationships. The Eigenvalue of the first and second canonical axes was equal to 0.23 and 0.18, respectively (Fig. 2).

Environmental variables which have an Eigenvalue over 0.5 seem to be quite effective for the other environmental variables and species composition. P, Ca and Mg have an Eigenvalue over 0.5 in the second axis. However, only clay content has a value over 0.5 in the first axis. The first axes was positively correlated with clay content. The second axes were positively correlated with P and Mg and negatively correlated with Ca (Table 1).
Swamp forests and soil properties

Fig. 1. The TWINSPAN clustering of species in the swamp forest, Northern Turkey, number of division and Eigenvalues were calculated according to Hill (1979).
Fig. 2. The CCA ordination diagram of species composition – environmental variables

- **Fraxino excelcioris-Fraxinetum angustifoliae**
- **Carpino orientalis-Pterocaryetum fraxinifoliae**
- **Acero campestris-Alnetum glutinosae**
Species diversity ($H'$) was high in all associations because the studied forest is a mesic one (4.29, 7.12 and 8.88 in Fraxino excelsioris- Fraxinetum angustifoliae, Carpino orientalis- Pterocaryetum fraxinifoliae and Acerio campestris- Alnetum glutinosae communities, respectively). Dooley and Collins (1984) stated that mesic sites in a deciduous oak forest in Oklahoma have higher diversity as compared to xeric sites.

Dooley and Collins (1984) also reported an average Shannon-Weiner index of 1.54 for bottomland Quercus forests in Oklahoma. In the studied forest, Shannon-Weiner index was considerably higher than that of the other forests (Risser and Rice 1971; Roberts and Gilliam 1995; Hoagland et al. 1996). High Shannon-Weiner index values were mainly related to the high water availability in the studied forest (Kutbay 2001). Evenness ($J$) values are found to be 1.19, 1.87 and 3.43 in Fraxino excelsioris- Fraxinetum angustifoliae, Carpino orientalis- Pterocaryetum fraxinifoliae and Acerio campestris- Alnetum glutinosae respectively. The differences in species diversity on mesic sites may be caused by an increase in resource availability, particularly light (Roberts and Gilliam 1995). The highest species diversity was observed in Acerio campestris- Alnetum glutinosae and this association usually consists of mesic herbs.

REFERENCES


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