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ECOLOGICAL INFERENCES FROM PHYTOSOCIOLOGICAL DATA IN AN ALLUVIAL FOREST ON THE PO PLAIN (Northern Italy)

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Abstract. The vegetation of an alluvial forest of the Po plain, known as the Forest of S. Agostino, has been surveyed using the Braun-Blanquet method. Analysis of the data revealed two main ecological situations characterized chiefly by differences in pedological factors identified by the cover values of *Carex pendula* and *Brachypodium sylvaticum*.

1. Introduction

This study is concerned with the vegetation of the Forest of S. Agostino, or "Panfilia" Forest. This is one of the few alluvial forest still existing in the Po plain. For this reason, its vegetation serves as a reliable model to describe the potential forest vegetation on the alluvial terraces of the plain.

A previous phytosociological study (Corbetta & Censoni Zanotti, 1974) ascribed the vegetation to the association *Carici-Fraxinetum angustifoliae* (Pedrotti 1970 ; Pedrotti e Cortini Pedrotti, 1978), without any subunit. Our paper reports on the results of a phytosociological study, performed to evaluate the ecological features through correlations between relevé groups and species groups. The results confirm the reliability of the phytosociological approach to supply information in an indirect gradient analysis.

2. The study area

The Forest of S. Agostino lies outside a meander that the Reno River forms just south of the village of S. Agostino in the province of Ferrara (Northern Italy).

The forest covers an area of about 50 ha on an alluvial terrace. The local climate has annual average rainfall of about 700 mm, with minima in February, July, and August. The average annual temperature is 12,9° C, with minimum in January (average 0.3°C) and maximum in July (average 23.4°C). These features are typical

of the climate of the Po plain. From a pedological point of view the soils are river sediments of silt, sand and clay. Wolf (1983) has shown that starting from the river bank, there exists a gradient from coarse texture soils, with good porosity, to increasingly fine textured soils, often very compact at the surface.

During the second world war the forest underwent extensive logging during which especially oaks were highgraded. Today the forest is mainly used for recreation and it is managed by the Azienda Regionale of Emilia-Romagna.

3. Materials and methods

Vegetation relevés were made according to the Braun-Blanquet method (Braun-Blanquet, 1964, Westhoff & van der Maarel, 1978). The relevés were classified by sum of squares clustering (SSA: Orlòci, 1967) using Euclidean Distance (Orlòci, 1978) after transformations of the cover/abundance values according to the van der Maarel (1979) scale: $r = 1$; $+ = 2$; $1 = 3$; $2 = 5$; $3 = 7$; $4 = 8$; $5 = 9$. All species were considered, except those occuring only in one relevè.

The correlation between relevè groups and species groups is discussed on the basis of the results of concentration analysis (AOC: Feoli & Orlòci, 1979), applied to a matrix of mean cover within species group in the relevè groups. An ecological evaluation of the relevè groups has been attempted by Landolt indicator values (Landolt, 1977) concerning the following edaphic factors: moisture (F), free H-ions (R), nutrient content (N), aeration (D), average light intensity (L). For every factor the significance of the differences between the mean values of the groups of relevès was tested by a t-criterion.

The taxonomic nomenclature follows Pignatti (1982).

4. Results

Treatment of vegetation data

A total of 39 relevés were considered in cluster analysis and three clusters were recognized in the dendrogram at the level of about 550 SS representing a classification efficiency of 30% (Fig. 1). We use these clusters as the main groups in further analyses. The species considered in the classification are 29. The dendrogram obtained with SSA (Fig. 2) shows 4 clusters at a value of about 700 SS. This value is nearly corresponding to the level chosen for defining relevé groups. The correlation between species groups and relevés groups, resulting from AOC, is given in Fig. 3. Species group S_4 is not related to a particular relevé group.

Ecological evaluations

Inference about vegetation ecology can be drawn from the results of AOC and the species indicator values (Landolt, 1977). The factors being considered are listed in Section 3. The indicator values weighted by the cover values gave the results in Table 2a. The results of t-tests applied to the mean indicator values of each relevé

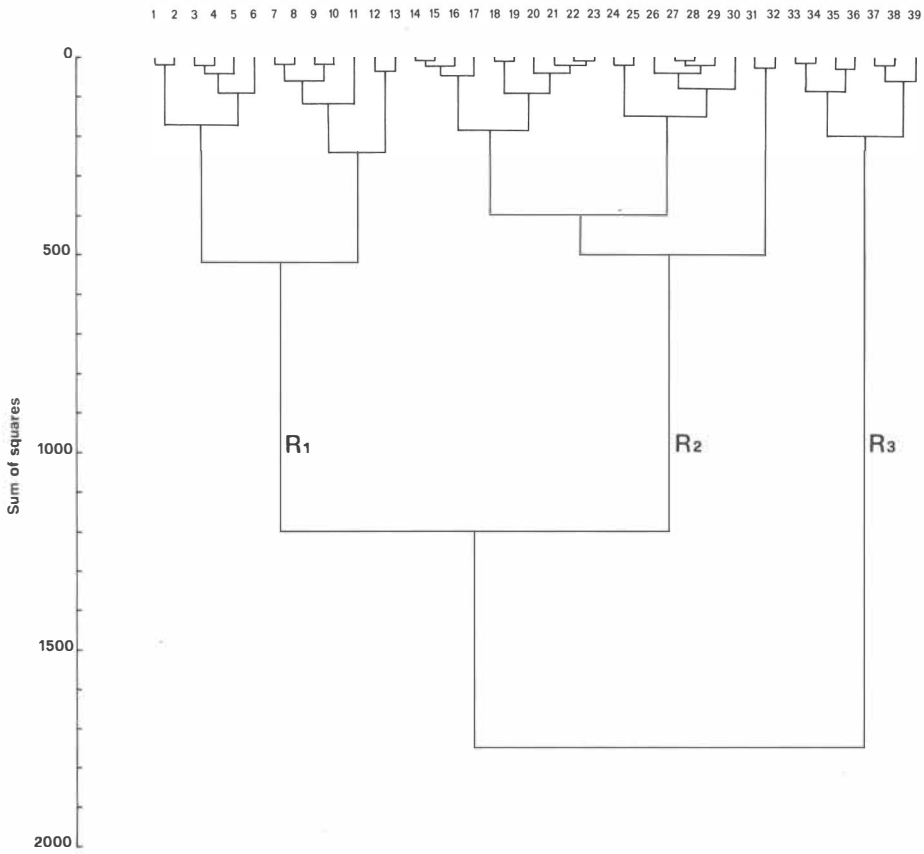

Fig. 1 — Fusion topology of relevés based on cover/abundance data. The clustering method is SSA. The R symbols identify major groups: the numbers are labels for relevés as in Table 1.

group (R_1, R_2, R_3) are given in Table 2b. We observe that: i) groups R_1 and R_2 differ only in soil acidity and aeration: group R_2 indicates weakly acid and more compact soils; ii) group R_3 is isolated. Compared with R_1 it represents more acid soils but when compared to R_2 it is more aerated, has more light, and drier soils.

From these results we conclude that the ordination of Fig. 3 can be explained by a prevailing particle size gradient and subsequent decreasing aeration in the sense of the sequence R_3, R_1, R_2. Interestingly these findings coincide with those observed by Wolf (1983), corresponding to an increasing distance from the river.

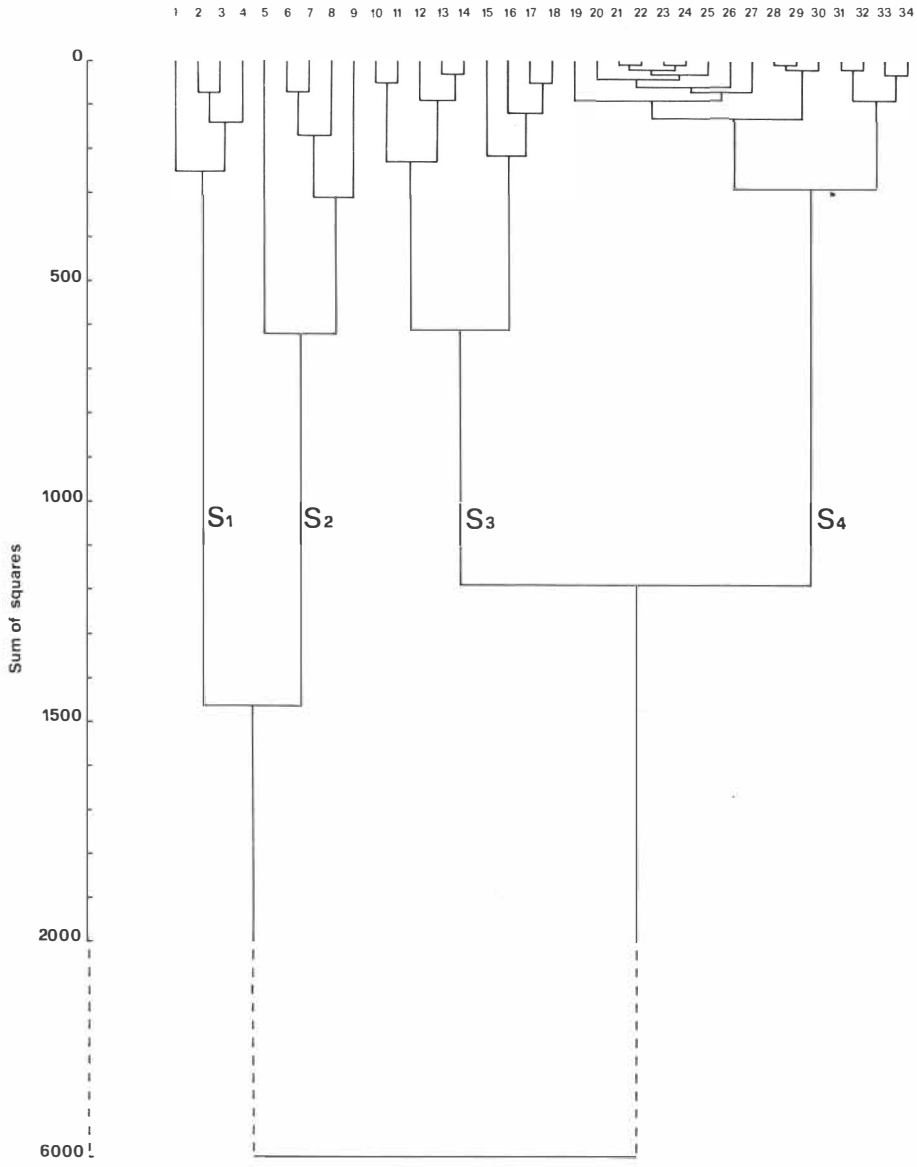

Fig. 2 — Fusion topology of species based on cover/abundance data. The clustering method is SSA. The *S* symbols identify major groups: the numbers are labels for species as in Table 1.

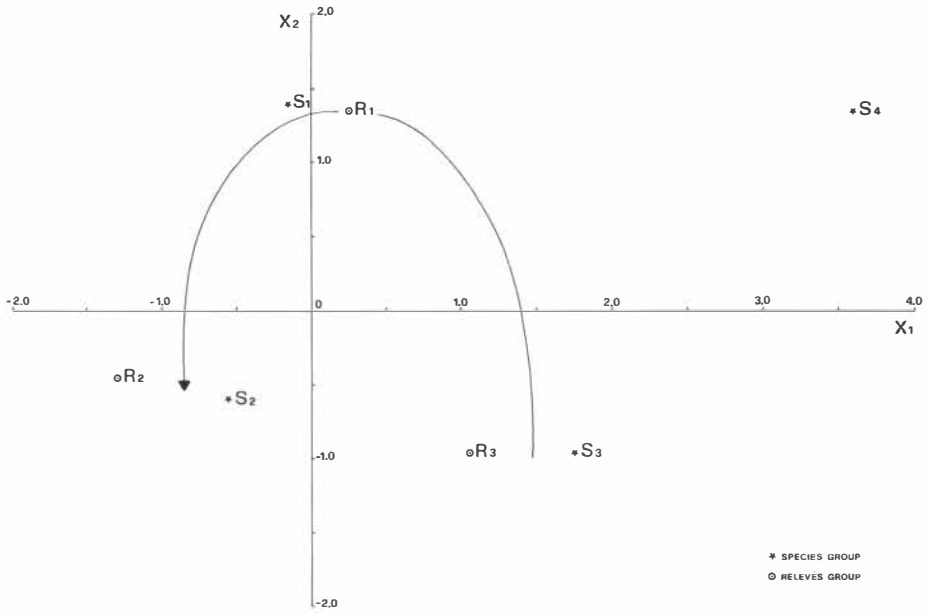

Fig. 3 — Reciprocal ordination od species and relevé groups according to the first two canonical variates. See explanation of the symbols in Tables 1 and 2. Further explanations are given in the text.

5. Conclusions

Which species are most useful to characterize the different ecological situations we have identified? It has been seen that a correlation exists between relevé groups and species groups, but only based on the magnitude of cover. It has also been seen that groups R_1 and R_2 are weakly differentiated. The situation with the highest particle size and the lowest acidity (R_1) can be tentatively recognized by the high cover values of species belonging to groups S_1 (chiefly *Quercus pedunculata* as a tree and *Prunus spinosa*) concordant with the high frequencies of some species of groups S_1, such as *Rhamnus frangula, Robiniapseudacacia, Acer campestris,* and saplings of *Quercus pedunculata* (see Table 1).

The identification of the ecological conditions of group R_3 is less ambiguous. On the one hand, the correlation between S_3 and R_3 is marked by a clear increase in the mean cover of *Brachypodium sylvaticum.* On the other hand, *Carex pendula*, with high covers in R_1 and R_2, drastically decreases its covers in R_3. We can conclude that, for a field prediction of the ecological conditions, the mean cover of *Brachypodium sylvaticum* and *Carex pendula* has high indicator value. Where the particle size is coarser, light intensity is higher, the soil more humid and richer in nutrients (R_3),

Table 1 — Phytosociological data according to the results of SSA. Relevé groups (- R_i) as in Fig. 1; species groups (S_i) as in Fig. 2.

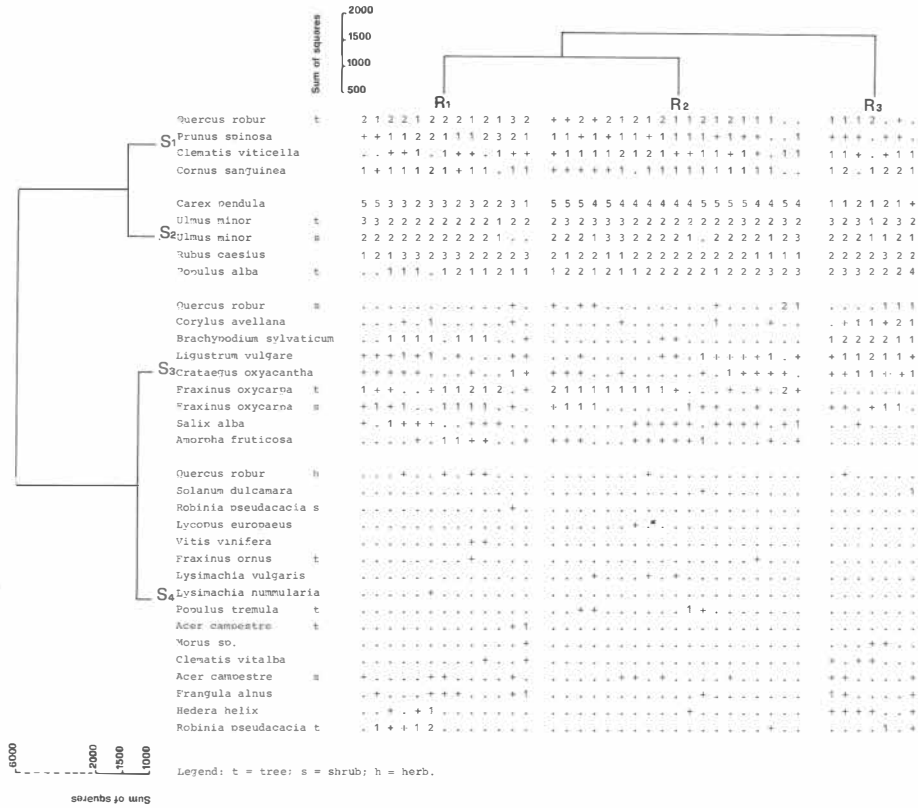

Table 2 — a) Average indicator values for the three relevé groups determined by the method of Landolt (1977).
Legend: *F*-humidity; *R*-free; *H*-ions; *N*-nutrients; *D*-aeration; *L*-light.
b) Significance of the difference between average indicator values of relevé groups based on a t-test.
*-significance at 5%
**-significance at 1%.

a)

	F	R	N	D	L
R_1	3.29	3.59	3.40	3.92	2.98
R_2	3.35	3.54	3.45	4.00	2.96
R_3	3.23	3.52	3.22	3.86	3.06

b)

	R_1	R_2	R_3
R_1	—	R*	R*
R_2		—	F** N** D** L**
R_3			—

Brachypodium sylvaticum and *Carex pendula* have similar cover values (from 20% to 40%). Where the soils are finer and light intensity, soil moisture, and nutrient concentration lower (R_2, R_1), *C. pendula* has high cover (up to 100%), but *B. sylvaticum* is only sporadic with cover up to 20% at the best.

The groups inferred from the phytosociological data, might be assumed as variants of the association *Carici-Fraxinetum angustifoliae* (Corbetta & Censoni Zanotti, 1974), corresponding to changes in the ecological conditions.

Riassunto. È stata studiata la vegetazione di una foresta golenale della pianura padana, il bosco di S. Agostino o bosco "Panfilia" (Ferrara) con il metodo di Braun-Blanquet. L'elaborazione dei dati ha evidenziato due situazioni ecologiche principali caratterizzate da differenze pedologiche. Queste situazioni possono essere individuate mediante i valori copertura di *Carex pendula* e *Brachypodium sylvaticum*.

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