EUROPEAN VEGETATION SURVEY - FROM THE METHODOLOGICAL DISCUSSION TO THE FIRST APPROXIMATION

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Abstract. - The methodological basis of phytosociology is discussed. This method for the study of vegetation was first proposed by Braun-Blanquet for the analysis of the floristic structure of plant communities and their synecology, but in the last decades floristic data have been emphasized, whereas ecological factors were more and more neglected. When the association is described only by floristic data, it appears as a chaotic system. New methods for vegetation analysis are described, based on the complementarity of floristic and synecological data. The use of the fingerprint approach to express ecological factors is discussed. It is proposed to construct the Vegetational Information System dedicated to the survey of plant communities in Europe. A model is proposed.
Key words - European vegetation, Syntaxonomy, Synecology, Vegetational Information System

THE HERITAGE OF BRAUN-BLANQUET AND TÜXEN

Phytosociology will be soon 100 years old. It was first proposed in Switzerland and in Montpellier at the beginning of the century and developed as a method for describing vegetation on the basis of species composition and ecology. As to its logical context, phytosociology remained a minor sister of plant taxonomy (Braun-Blanquet, 1928). Most students of phytosociology, mainly in the pioneer phase, were also skilled taxonomists (e. g. Braun-Blanquet, Pawlowski, Horvatic, Gams, Rivas-Goday) and phytosociology has taken from plant taxonomy the emphasis on rare species, the need for a Latin nomenclature, the need for a hierarchic system (syntaxonomy) and the general biogeographic background. Only in recent years the term vegetation science started to be used (van der Maarel, 1990). With the experience of the following period it is now possible to discuss the methodological heritage of phytosociology which can be considered still alive in a rapidly evolving scientific framework.

The main interest of phytosociology is the knowledge of the habitat or of environmental factors specific for the habitat (Pignatti, 1980). The direct measure of environmental factors by physical and chemical methods is possible, but immensely complicate, and in consequence the evaluation of habitat is obtained by the use of indicators.

The theoretical basis for phytosociology is given by the fact that species are assumed as indicators.

As an indicator, every species describes its own ecological space. Consider now a whole of several species with similar ecology: they describe an area of overlapping which is smaller than the area of single species, but more informative because of the occurrence of different species (Fig. 1). This whole is called “vegetation” and consists of individuals of plant species living together on a site where ecological factors are compatible for every of the components (Westhoff, 1970). Vegetation is composed by species and is ultimately the more informative indicator of ecological conditions in the habitat.

The main tools for the phytosociological study of vegetation are: association and character species. The association is recognized by the presence of character species, and species are focussed as the most significant aspect in phytosociology. In our opinion most of the recent literature on European vegetation is based mainly on floristic information. The present paper is a description of an alternative approach, based on the equilibrate interaction between biodiversity (species combination) and synecology (ecology of the habitat of a whole of several species).

THE NEED FOR A SYNTHETIC SURVEY

The idea that associations are biological units which can be typified and described in analogy to species was developed since the pioneer epoch at the beginning of this century and in the Thirties the need was felt for a published handbook describing all associations known up to that moment. The publication of Prodromus (Braun-Blanquet, 1933) was dedicated to monographic subjects, and almost at the same time the first survey of all associations occurring in a large area such as NW Germany was published (Tüxen, 1937). These first publications were followed by many more after the Second World War, but always on the basis of studies which were limited to a single geographic region or to a single subject, so that presently a general description of all associations is available only for Germany (Pott 1992). In consequence, a synthetic overview of the European vegetation is still lacking. A different, but strongly related issue is that the bodyes responsible for environment in the EU have an urgent need for habitat classification. The document CORINE was produced in 1991 and followed by the Paleartic Classification (Devillers and Devillers Terschuren, 1996) and presently an improved version EUNIS is in progress (Moss and Davies, 1997); vegetation is considered a significant descriptor of habitat types. The redaction of the European Vegetation Survey is the main aim of the Rome Workshops (Pignatti, 1990).

The need for a synthetic survey is very urgent both for scientific and practical purposes. Indeed the task appears more difficult year after year because of the steadily increasing number of associations described by the Authors. For every association a vegetation table with a number of relevés is given. At this moment there is no reliable evaluation of the total number of associations described, but they can be estimated around at least a few thousands just for Europe. The number of relevés is much higher, problably from 500,000 to one million. The treatment of this material by a single author or in a centralized institution, even with the most sophisticated computer procedures, seems impossible. In addition, the complete publication of a synthetic overview with the redactional style used for regional surveys would amount to an enormous work and thus surpass any possible funding. At this point, new possibilities for information storage and retrieval must be discussed.

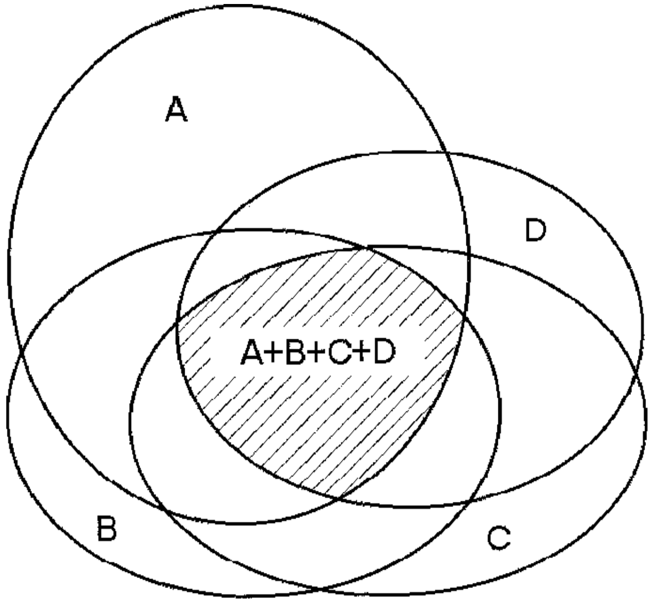


Fig. 1 - The ecological distribution of 4 species is plotted as dependent from 2 ecological factors (as a simplified model). The probability to find these species by chance corresponds to their frequencies: 0.5, 0.4, 0,3 and 0,2. If the four species belong to an association, their areas overlap. In this case the probability of the combined presence drops to 0.012. The combination becomes highly significant (from Pignatti, 1998).

Some critical points of the traditional methods for phytosociology can be pointed out in short:

computer-assisted methods - a useful software has been developed and is generally used: this has enabled a valid standardisation of methods for relatively limited topics (a group of similar syntaxa, a region), however this software is not suited for the treatment of large sets of data, as the vegetation of the whole continent;

indication value - the presence of species in a community is not a deterministic fact, and consequently in a majority of cases this seems mainly an effect of chance (at least for the sporadical species): the indication of ecological factors through the presence of species is valid only for such species which are "good" indicators, but an objective criterion to distinguish good indicators does not exist;

nominalism - communities are labeled with Latin names followed by author's quotations, this gives an impression of scientificity which is not always true; other branches of science (e.g. Chemistry or Geology) are progressing very well without being strictly bound to a formalized nomenclature;

syntaxonomy - in current phytosociological literature syntaxa have been described without general rules and in a very heterogeneous manner; some rules were proposed only for the nomenclature, but without a previous statement on the validity of the syntaxon itself; this means that every syntaxon is validly described only if it is published in a recognised bibliographical source, if a type is indicated etc.; these are formal requirements which do not concern the substance, in consequence the undiscriminated use of published syntaxa can lead to severe confusion; otherwise, syntaxonomy gives the most informative basis for the ordination of thousands of associations;

cartography - a mature technology, based on methods which have been used for fifty years and more, where important progresses can be hardly expected; indeed, the rapid development of remote sensing will probably produce in few years completely new procedures operated by technical personnel; as a consequence, botanists will be excluded from this important field of work.

The possibility to understand the indication value of species and of species combinations is a big asset for scientists using the phytosociological approach in vegetation science. New points of view and new methods are necessary, if we try to maintain an adequate audience as experts in the problems of environment.

THE FLORISTIC APPROACH: PLANT COMMUNITIES AS CHAOTIC SYSTEM

In the traditional phytosociological method, and in particular in the scientific production of the last decades, the association is described with a table of relevés: i.e. a matrix species x sites including numbers which indicate the abundance of the species (estimated with whatever method) in the given site. This document is clear for anyone having experience with the ecology of the listed species: the presence of *Nardus stricta* indicates an acid soil, *Euphorbia dendroides* a sunny mediterranean rock. What about a phytosociological table of an unknown flora, e.g. from another continent? Floristic data alone in this case convey hardly any information (even for a skilled student of vegetation science) on the relationships between vegetation and its habitat.

It is a normal experience, that the complete set of data included in the phytosociological table is taken into account only in the case of computer assisted analysis; otherwise, tables are not read in detail and only the dominant species are examined carefully; sporadic species are considered more or less as noice. Indeed, the phytosociological table is a document which has to be considered in its complete content; if data are neglected, this causes a loss of information. In a more general sense, we came to the statement that phytosociological tables are documents which cannot be shortened without a loss of information.

Following the system theory, a document which can be reproduced only by its complete description can be considered as a non ordered system i.e. a chaotic system (Ford, 1992). This is the condition of most of the recent phytosociological literature. In our opinion this is not sufficient to conclude that vegetation is really a chaotic system. It means, that if vegetation is described only by floristical data, then it appears as a chaotic system. Or, better: the order inherent to vegetation is not expressed by a merely floristic description.

Under these circumstances it seems that a phytosociology which was based mainly on the description of the floristic structure of vegetation (as it has commonly been up to the present) neglected the underlying principle of order, and allowed an endless analysis while making every attempt to synthesis difficult. For this reason we propose the alternative approach based on the causal analysis of biodiversity and synecology instead of a mere description of phaenomena.

THE BIODIVERSITY/SYNECOLOGY APPROACH: PLANT COMMUNITIES AS COMPLEX SELF-ORGANIZING SYSTEM

The causal analysis of the plant community has to be based on an integrated view, including both biodiversity (floristic information) and synecology. In a vegetation stand there are plants, growing together, and most of them have the tendency to grow and expand. Growth always produces a higher organization in the plant canopy. The succession from pioneer annuals, to perennial herbs, shrubs and forest is a process of increasing organization. The vegetation can be consequently interpreted as an example of a complex system (Pignatti, 1995[1]) with a high degree of self-organization (fig. 2).

Vegetation can be considered as a system concentrating order. The turnover in vegetation produces effects on biodiversity and on synecology (Pignatti, 1996[2]). A number of selection processes as coordination in space, integration of niches and concurrence, result in the production of biodiversity. In synecology, order accumulation is the consequence of a general tendency to control environmental factors through the organic constituent of vegetation: this is mainly a consequence of microclimate buffering through the vegetation canopy and buffering of soil factors through humus deposition and the construction of the soil-vegetation continuum.

When it is conceived as the complex system of plant individuals operating in the ecosystem, vegetation appears highly ordered, and this order can be explained as an effect of functions with generalized significance. In this case a concise description of the system becomes largerly possible. In fact, the description of the different functions needs few words, and in a more general sense this can be done using an appropriate language including flow diagrams, chorograms, morphograms

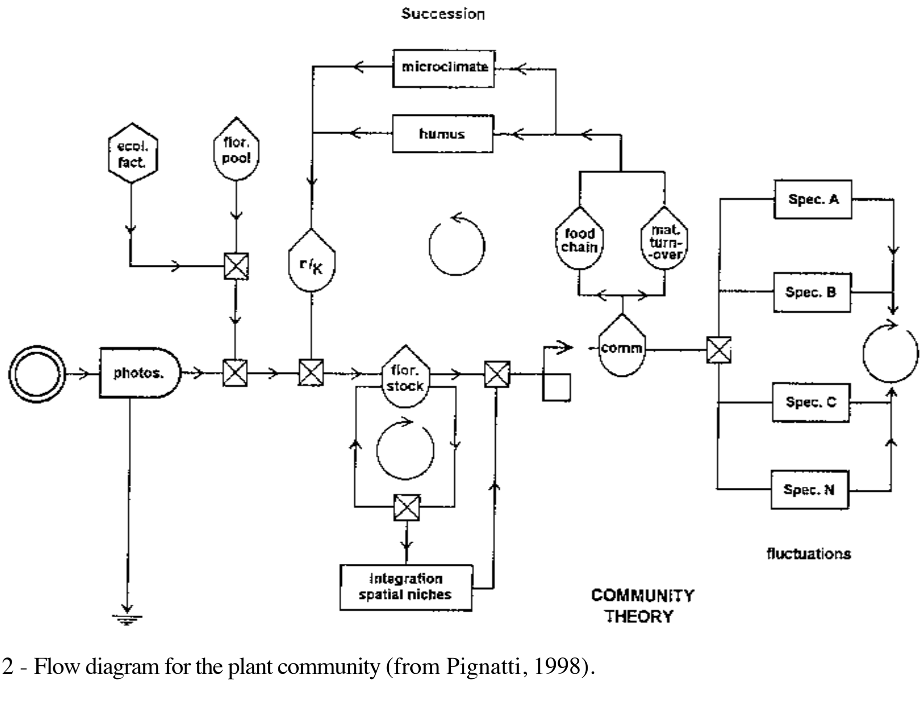


Fig. 2 - Flow diagram for the plant community (from Pignatti, 1998).

and ecograms. Nothing is farther than the image of a chaotic system.

THE ASSOCIATION: FROM FLORISTICS TO COMPLEX SYSTEM APPROACH

Returning from considerations about the method to what is more relevant for the EVS (European Vegetation Survey), considering what was exposed above we come to the conclusion that the common way to describe associations on the basis of vegetation tables is inadequate, because it points out the chaotic aspects while neglecting the principles of order which are necessary to understand any concept. Floristic description alone is not the adequate language.

The same can be said for syntaxonomy. There are limited possibilities to understand, memorize and give an opinion on chaotic systems, and consequently syntaxa often consist of very few components, i.e. an alliance of 3-5 associations, a class of 2-3 orders etc. The consequence is that the system is loaded with units which are often difficult to recognize and partly overlapping; in many cases other syntaxa are introduced e.g. sub-orders, sub-alliances with increasing complication; such complex hierarchy mostly appears as the projection of a mental scheme. Indeed, there are no limits for the number of associations which can be included in a single alliance. Taking species systematics as a model, there are genera (*Carex, Ficus, Solanum*) with 1000-1500 species: similarly, a single alliance may include hundreds of associations if necessary. This does not exclude the possibility to describe specialized groups (without a formalized nomenclature), in order to give evidence to some floristic or ecological feature.

Thus a new language is needed. The problem is that systems are complex and consequently complex phenomena have to be represented.

EVS AS VEGETATIONAL INFORMATION SYSTEM

We propose to organise an improved information system using the Internet facilities which should be able to include a general level of information on the vegetation of Western Europe but with such characteristics as to become extensible to the whole of Europe or Eurasia or even to the whole world vegetation: the Vegetational Information System.

The classification should be strictly hierarchical, based on presence/absence of species; no exceptions are admitted, in order to obtain an unambiguous result; every syntaxon must be placed in a given unit on the basis of the presence of one or more indicator species.

The system must be structured on the presence-absence of species - as is tradition in phytosociology - and on information derived from morphology, chorology and ecology of the vegetation. These four main features must always be present in every description.

The main framework must be based on the hyerarchic structure which is familiar to every scholar working with phytosociology: class, order, alliance, association, organized in a tree. At the beginning of the tree, general informations are given and the identification of vegetation classes follows, based on dicotomies, on morphology, chorology and ecology. This way it is possible to identify the relevant classes (for Europe probably 50-60 classes will be used) and to recall it on the screen page. It contains general information, bibliography and a new dicotomic tree which leads to the orders. Similarly, the screen page of order in analogy leads to the alliances. The screen page of alliances is more complicated and in addition to this information it contains also a synoptical table of all associations known for a given alliance. In consequence the identification of the associations is not made with a dichotomic key but with direct comparison with a species list and with the presence of character species. The screen page for associations (fig.3) is elaborated with a rigid scheme which remains unchanged for every type of vegetation, from pioneer discontinuous settlements to grasslands, forests and synanthropic associations figure 3 (see Parametrisation). For every level additional information can be added on separate sheets as well as graphic tables and photos; the system is based on the use of a coloured screen.

An important item is the research of a given vegetation type among hundreds of others. The procedure described is deductive, but it will be possible to locate a syntaxon by its name or synonims or with an intelligent program based on species combinations: for instance “indicate the nearest associations to *Fagus* 90%, *Melica nutans* 30%, *Mercurialis perennis* 45% etc.”

SYNTAXONOMY: THE RULES OF THE GAME

The tree structure to be used needs to revisit syntaxonomy. The main structure will remain unchanged, but it seems necessary to keep strictly to general rules, in order to obtain a simplification of overlapping units. Up to the present, the definition of syntaxa was given in a more empirical way and a recent discussion exists only for the class (Pignatti, Oberdorfer, Schaminée & Westhoff, 1993). Order and alliance have to be treated in analogy. On the basis of the previous experience (mainly by Braun-Blanquet and Tüxen) one of us proposes (Pignatti, 1998) some general rules which appear necessary for associations in order to be recognized and ordered by automatical methods. These rules can be extended also to the level of alliance, order and class. They mostly correspond to the common use in the present, but have to be stated clearly in setting up an informative system.

- only those communities are treated as associations which have their own ecological space and a definite floristic composition (both facts are connected).
- syntaxa of any level are recognised by particular bioindicators which are called character species.
- character species are only those which are recognised at the species level in currently used floras e.g. Flora Europaea, or rarely have infraspecific rank (sub-species, variety etc.)
- only such species which occur exclusively in one syntaxon or occasionally also in other syntaxa can be considered as character species (if occurring in other syntaxa, then in a different biogeographical zone).
- ecologically distinct syntaxa should be differentiated; syntaxa not differing ecologically should not be separated unless they include different character species.
- never will a species of the same biogeographical area be considered as a character species for two different syntaxa of any level belonging to different classes
- in addition to character species, syntaxa are recognised by differential species which occasionally may be character species in other classes, but a syntaxon cannot

be defined only by differential species and in absence of its own character species.

For the latter rule some exceptions must probably be accepted to avoid an abrupt change in generally recognized syntaxa.

PARAMETRISATION OF VEGETATION UNITS

The syntaxa should be described using a completely uniform scheme so that every syntaxon can be easily compared with any other of the same level. This is particularly important for associations. In fact some examples of description on standardised sheets were proposed in earlier literature, for instance by Ellenberg and Kloetzli (1972) for the forest vegetation of Switzerland and by Rameau (1994) for France. In Fig. 3 we propose a improved version of the standard used in our treatment of the forest vegetation of Italy (Pignatti, 1998) which can be contained in just one screen page. In the left column it contains all relevant information on character species, environment, stratification, diversity, distribution, threats etc. and in the righthandside column a geographical map, the fingerprints (ecogram, chorogram and morphogram) and a shortened synoptic list with the frequency of species occurring in more than 20% of relevés.

The parameter frame includes the following informations (see Appendix). The screen page can be developed using commercial software, e.g. Microsoft Access. Particular attention must be given to the possibility of cross-references.

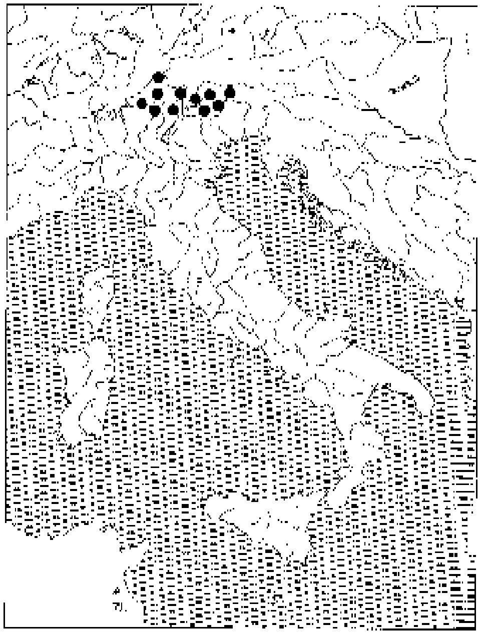
CONCLUSION

Since EVS was proposed in 1990, many problems have been discussed, clarified and mostly solved. The starting point was the idea to produce a work, in the form of book, containing the description of the European vegetation in the more or less traditional form of the existing examples of regional or national Prodromus-like publications. The vegetation of the British Isles would need 5 volumes, the Netherlands 4 volumes, SW.Germany 4 volumes plus 1 of tables, Japan 10 thick volumes etc. A prudential prevision for the whole of Europe would consist of 30-50 volumes. This task completely exceeds the possibilities of the present, as to manpower, funding and publication opportunities.

The reason of such a paradox situation is that in most recent literature vegetation is treated only on the floristic information. In this condition vegetation appears as a chaotic system and needs a detailed description, which cannot be shortened without the loss of essential information. The possibility to include synecological information (fig. 4) opens completely new perspectives. Considering synecological information, vegetation acts as an auto-organizing system and its description can be done in a more concise form. EVS can result from cooperative work of different Authors on the Internet using new languages (fingerprint representation, screen pages, parametrisation). The final goal is the construction of the Vegetational Information System. Prints containing information about the most actual problems may then be obtained at any time from the stored information.

1. *HOMOGYNO-PICEETUM* Zukrigl (1973)

Pecceta subalpina



SINONIMI: *Piceetum subalpinum*

CORINE: Bilberry spruce forests: 42.211 (per le peccete dell'Appennino settentrionale: 42.242)

ALBERO DOMINANTE: Peccio (*Picea abies*)

STAZIONE: altopiano, pendio, conca

CARATTERI DIAGNOSTICI: alto fusto con dominanza di *Picea abies* e denso sviluppo degli strati basso-arbustivo e muscinale

SPECIE CARATTERISTICHE: *Listera cordata, Luzula luzulina*: per le piccole dimensioni spesso richiedono un'attenta ricerca

ZONA: centroeuropea

FASCIA: boreale

TIPI DI PAESAGGIO: Dolomiti interne, Alpi trentine e lombarde

ALTIMETRIA: (1200)-1500-1700(1800) m

ESPOSIZIONE: NW-N-NE-(E)

INCLINAZIONE: 0-10(20)°

STRATIFICAZIONE:
- A (15)20-25(30) m – (50)70-90%
  B 3-5 dm – 30-50
- C 1-5 dm – 30-50
  D (manca)

ALL.: *Piceion abietis*

ORD.: *Piceetalia abietis*

CLASSE: *Vaccinio-Piceetea*

DIVERSITÀ SPECIFICA: 21-35, med. 27 sp./ril.

TABELLA DI REFERENZA: Dolomiti, tab. orig. (non pubbl.) 37 ril.; Br. Bl., Pallmann e Bach (1954) tab. XII ril. 1-19, tab. XIII

SUBASS. E VARIANTI: *linnaeetosum* (var. a *Vaccinium myrtillus*; var. a *Vaccinium vitis-idaea*), *avenelletosum*

STADI SUCCESSIONALI:
PRECEDENTI: in successioni secondarie si sviluppa da *Nardetum* oppure *Adenostyletum* (var. aa) oppure *Berberidion* e lariceti (var. ab)
SUCCESSIVI: climax

DISTRIBUZIONE: dalla Carnia occidentale alle Alpi lombarde

SUOLO: podsol più o meno completamente sviluppato. Per uno studio dettagliato cfr. Br. Bl., Pallmann e Bach (1954), p. 171

RUOLO SELVICOLTURALE: produzione legnosa, difesa dell'equilibrio ambientale, tutela del paesaggio, fauna, frutti del bosco, turismo e tempo libero

RISCHI: piogge acide

A:	**Picea abies**	100%
B1:	Vaccinium myrtillus	100
	Vaccinium vitis idaea	87
	Sorbus aucuparia	78
C:	Oxalis acetosella	87
	Homogyne alpina	83
	Hieracium sylvaticum	83
	Calamagrostis villosa	74
	Avenella flexuosa	71
	Luzula luzulina	67
	Dryopteris assimilis	63
	Luzula sieberi	56
	Melampyrum pratense	56
	Majanthemum bifolium	53
	Melampyrum sylvaticum	44
	Lycopodium annotinum	40
	Listera cordata	37
	Prenanthes purpurea	37
	Gymnocarpium linnaeanum	37
	Luzula albida	37
M:	Hylocomium splendens	100
	Rhytidiadelphus triquetrus	100
	Dicranum scoparium	93
	Plagiochila asplenioides	63
	Polytrichum attenuatum	53
	Cladonia sylvatica	44
	Cladonia pyxidata	40

LEGENDA (valida per tutte le schede):
● – specie dominanti nello strato indicato (es. **Picea abies**)
○ – specie a bassa copertura (es. Luzula albida)

Fig. 3 - EVS Association Model. This is a possible example of a parameter frame, mainly obtained from the parametrisation of the forest vegetation of Italy (from Pignatti, 1998).

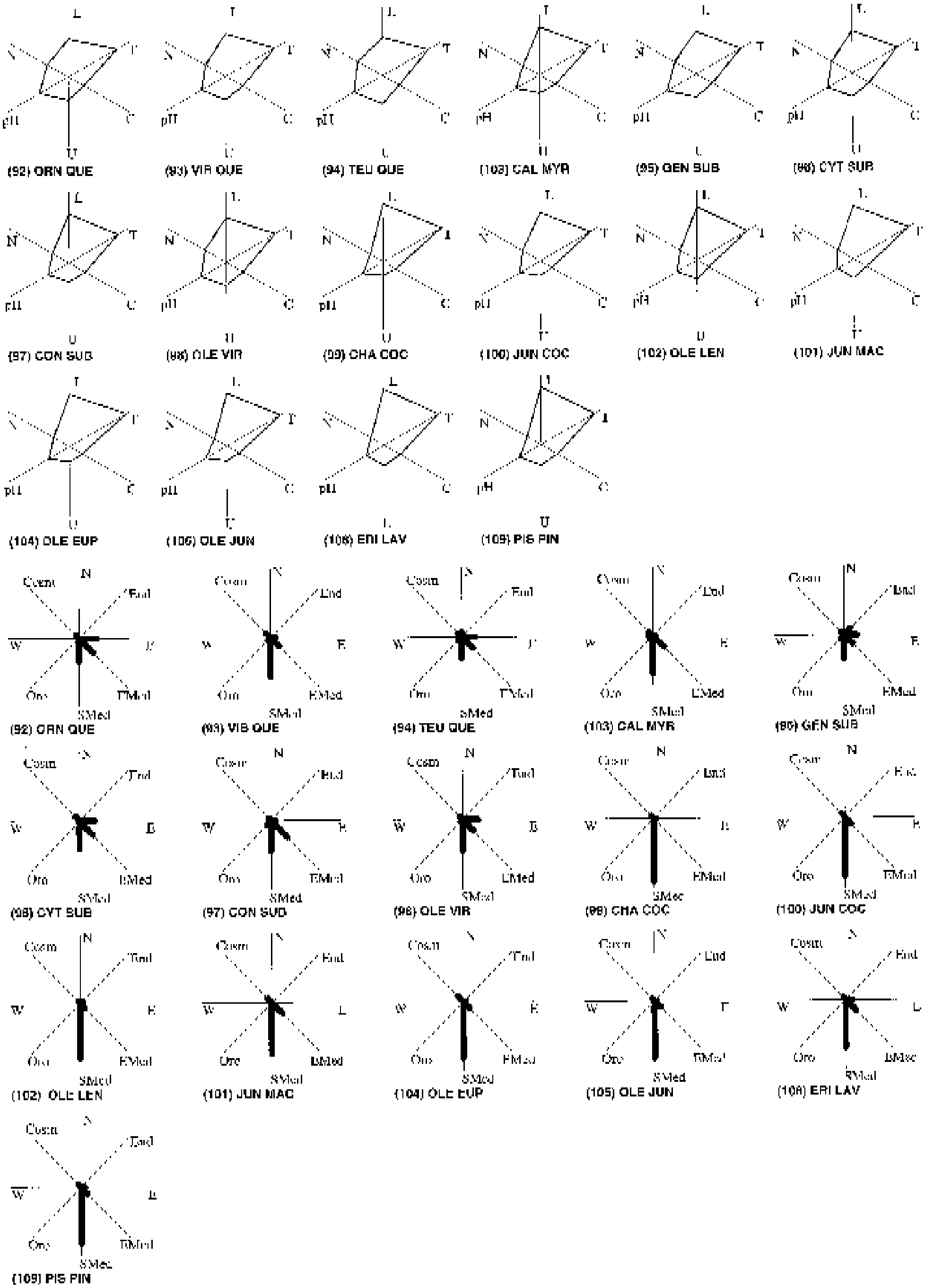


Fig. 4 - Ecograms and chorograms for 16 associations of the evergreen forest vegetation in Italy. - Ecogrammi e corogrammi per 16 associazioni di foresta sempreverde in Italia (da Pignatti, 1998).

A first example was recently published (Pignatti, 1998). It is possible that in short other prototypes dealing with particular syntaxa may be produced.

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APPENDIX

a - identification descriptors
- name
- authorship
- code
- code in EU habitat classification
- synonims in common use
- definition in non-technical language (english)
- id. in the local language
- main features of the site (text description)
- main vegetation features (text description)
- syntaxonomy
- type locality

b - distinguishing characteristics (chemical and physical parameters)
- climate
- geology
- biogeographical zone
- landscape unit
- altitude of the site
- depth (only marine vegetation)
- exposure
- slope
- soil type
- salinity
- ecology of the site (text description)

c - distinguishing characteristics (biotic parameters)
- dominants (if any)
- character species
- stratification
- diversity
- life forms
- chorotypes
- Ellenberg's Zeigerwerte
- vegetation subunits (subassociations, variants, facies etc.)
- vegetation belt
- succession
- synoptic list

d - informative data
- geographical distribution
- significance and function in vegetation
- context
- fire ecology
- grazing
- human impacts
- threat factors
- threatened plant species
- faunistic relationships
- literature

e - fingerprints
- geographical map
- chorogram
- morphogram
- ecogram