An ecological classification of floristical relevés by coupling a regional survey with a national data bank

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ABSTRACT: The proposed method is based only on floristical data and nevertheless classifies the relevés into ecological groupings, corresponding to as similar environments as possible. It begins by calibrating the behaviour of each plant along a large gradient, in a national data bank of floristical relevés, on the scale of France, the bank Sophy. It calibrates the behaviour of a plant by its fidelities to the 5.626 other plants of the bank, which are considered as indices of the environment. It defines a statistical space having 5.626 dimensions in which: 1) an axis measures the fidelity to a plant, considered as an ecological index; 2) a dot corresponds to the behaviour of a plant towards the indices; 3) the distance between two dots expresses the ecological difference between two behaviours; 4) the centre of gravity for the plants of a relevé indicates the probable position of the relevé; 5) the distance between two relevés expresses their ecological difference.

Compared with this method, the correspondence factor analysis CFA: 1) locates the relevés in a space, according to the fidelities of plants to relevés, showing their floristical differences; 2) gives a weight to a plant according to its rarity, not its ecological behaviour; 3) deals only with subsets of the relevés and rehandle the subsets by successive approximations; 4) transfers onto the graphs the empirical and intuitive method of a naturalist during field-work.

The method is applied to about 400 relevés in a district in the Northern Vosges (France). It generates an automatic classification of the relevés, at several levels of synthesis, including the upper levels above the phytosociological classes. It explains half of the peculiarity of a type of plant community with 10 to 30 discriminant plants, which are the quantitative and gradual homologues of characteristic species.

KEY WORDS – Socio-ecology, Discriminant plants, Fidelity.

INTRODUCTION: WHY AN ECOLOGICAL DATA PROCESSING IN VEGETATION SCIENCE?

Vegetation science is a self-reliant discipline which deduces a synthetical picture of vegetation from the coexistence of taxa in the plant communities. It has the ambition to give a picture of vegetation which is also a picture of the environment, though it does not have standardized ecological data at its disposal in the whole set of floristical relevés. It may fulfil its ambition by adapting an ecological method to vegetation science. At first sight, this method might seem too much ecological and too much complicated. The method seems too much ecological to people which presume that it uses ecological data, as the data coming from a calibration (Ellenberg, 1974). In fact, the method uses only floristical data, as the classical methods always do. The method seems too much complicated to people which are accustomed to the standardized results of factor analysis. In fact, the method is more simple than factor analysis, and it is adapted to vegetation science (Brisse *et al.*, 1984).

1. An ecological classification of floristical relevés

1.1. *Aim of the classification: Quantifying the ecological differences in vegetation science*

The aim of the classification is to obtain a correspondence between a type of plant community and a given environment. With this objective, the classification respects two specifications: 1) It is based only on presence and abundance of species in the relevés; 2) it quantifies the global ecological differences between the relevés with only the floristical data. But the difference between the floristical compositions of two relevés depends not only on their environments but also on the casual intermittence of the dissemination, and consequently it depends on the size of the relevés. Moreover, the floristical difference is based only on the numbers of plants which belong to one relevé or the two of them, whereas an ecological difference should weigh the ecological behaviours of the plants and give to the difference between two opposite behaviours a larger importance than between two close behaviours.

1.2. *Principle of the classification: to localize the plants and the relevés in the space of the fidelities of plants to plants*

1.2.1. Space of the fidelities of plants to plants

Because vegetation science does not dispose of standardized data about the environment, it cannot characterize directly the numerical behaviour of a plant towards a peculiar environment. But it may characterize it indirectly, if it considers a plant, in turn, as an index and as an effect of the environment. Considered as an index, a plant is the mark of a more or less precise type of environment, which allows the plant to grow. Considered as an effect of the environment, the behaviour of a plant is characterized by the distribution of the plant amongst the different types of environment. Such a behaviour is numerically expressed by the set of fidelities of the plant to the indices of the types of environment, that is to say the fidelities of the plant to the other plants. The difference between two sets of fidelities expresses the difference between two ecological behaviours. The set of fidelities of plants to plants define a statistical space having as many dimensions as there are plants. In this space: 1) a dot corresponds to the behaviour of a plant; 2) the distance between two dots expresses the difference between two behaviours; 3) the centre of gravity of the plants of a relevé indicates the probable position of the relevé; 4) the distance between two relevés expresses their ecological difference and allows them to be classified in types of plant community having homogeneous environments.

The average fidelity of a relevé to a plant, which is the coordinate of the relevé in the statistical space, is nothing else than the probability for the plant to be in the relevé, in relation to all the plants of the relevé and to their probabilities of mutual occurrence in the whole set of relevés. Moreover, the average fidelity evolves gradually along a transect, and it lowers the fluctuations coming from the casual intermittence of plants.

1.2.2. Why the notion of fidelity is it extended?

The first and well known fidelity is the fidelity of a species to a type of plant community. It has been recognized as the main statistical criterion in the classification of the plant communities, by successive approximations. The notion of fidelity has been transposed to ecology, then back to vegetation science, in order to give an ecological meaning to the relations between the relevés, and to reach the accuracy and objectivity of computerized results (Table 1). In that way, a group of relevés is characterized by its average fidelity to every species. It may seem to be the reverse of the classical notion which defines the fidelity of a species to a group. It is not the reverse, but the same idea of dependency, extended to a multi-dimensional space.

1.2.3. Is there a vicious circle?

It may be asked whether this method includes a vicious circle, whereas it defines the environment according to plants, then it characterizes the plants according to the environment. In fact, the method characterizes only the plants by the plants, according to the basic idea of vegetation science. It just distinguishes, between the floristical differences, the part ascribable to the environment and the casual part from an ecological point of view. The differences which seem to come from the environment follow a coherent variation, as an ecological variation. On the other hand, the floristical differences which are disconnected and inconsistent do not reflect a systematic variation. It is so for two relevés which have different floras but similar positions in the space of fidelities.

TABLE 1
EXTENSION OF THE NOTION OF FIDELITY

	PLANT SOCIOLOGY	PLANT ECOLOGY	PLANT SOCIO-ECOLOGY
Taxonomic variables	Species	Environments	Plants = species with abundance thresholds
Scope of the fidelity **F**	Fidelity **F** of a species **A** to a type of plant community **C**	Fidelity **F** of a species **A** to a feature **E** of the environment	Fidelity **F** of a plant **A** to another plant **B**
F means the apparent dependancy ...	... of **A** to the environment shown by **C**	... of a species **A** to a feature **E**	... of **A** to the environment shown by the plant **B**
Characterization of a relevé	The fidelities of its species to the groups in a previous hierarchy	The average fidelity of its species to every feature **E**	The average fidelity of its plants to every plant **B**
Determination of a vegetation type	by successive approximations, according to the fidelities of species	Hierarchical classification of the relevés in the space of the fidelities **F**	Hierarchical classification of the relevés in the space of the fidelities **F**

1.3. *Comparison with the correspondence factor analysis CFA*

The most familiar statistical method in vegetation science, as in the most diverse fields, is the correspondence factor analysis CFA (Lacoste, 1975). CFA shows some similarities with the proposed method. 1) It locates the plants and the relevés in the same multivariate cartesian space. 2) In that space, it computes distances between the relevés. So, it avoids preconceiving the groupings and it makes use of the power of informatics. 3) It computes the distances according to frequencies which seem to be similar to the classical fidelities of plants to the types of community. But CFA relates the frequencies to the relevés, not to the types of community, so they differ in meaning from the classical fidelities.

1.3.1. The distance computed by CFA expresses a floristical difference, and has only a partial ecological meaning

The distance computed by CFA between relevés varies in inverse ratio to the simple coefficient of floristical similarity, if we leave the balancing coefficients out of account and if we suppose that the relevés have the same number of plants and that the plants occur in the same number of relevés. In such a case, the distance computed by CFA depends only on the number of plants which are present in one relevé and absent from the other (Table 2). The distance expresses the difference

TABLE 2

COMPUTATION OF DISTANCE D BETWEEN TWO RELEVÉS BY CORRESPONDENCE ANALYSIS

n(t) = total frequency of taxon t. r1, r2 = floristical effectives of the relevés 1 et 2

t = number of a taxon. tx = total number of taxa.

p1(t), p2(t) = présence of taxon t in the relevés 1 et 2.

$$D2 = \Sigma\ (1/n(t)) \times (p1(t)/r1 - p2(t)/r2)^2 \text{ for } t = 1 \text{ to } tx$$

Comparison between distance D and the coefficient of floristical similarity C leaving the balancing coefficients of CFA out of account: r1=r2 and n(t) = constant

$$D^2 = \text{constant} \times \Sigma\ |p1(t)-p2(t)|^2 \text{ for } t = 1 \text{ to } tx$$

$$C = 2 - 2 \times \Sigma\ |p1(t)-p2(t)| \ / \ (r1+r2) \text{ for } t = 1 \text{ to } tx$$

For D as for C, the only variation comes from $\Sigma\ |p1(t)-p2(t)|^2$, or from $\Sigma\ |p1(t)-p2(t)|$ which is nothing else than the number of plants which are present in one relevé and absent from the other.

between the floristical contents, without discriminating the systematic effect of the environment from the casual fluctuations within the same environment.

1.3.2. CFA balances the plants by their scarcity and split the relevés in successive subsets

The balancing of plants by their scarcity is necessary in CFA but not in vegetation science, because scarcity does not measure the indicator capability of a plant. With such a balancing, a scarce plant masks the differences coming from the other plants. It obliges one to withdraw the scarce plant and its relevés from the computation, and to remake another computation, where another plant becomes scarce, and in turn disturbs the results, and so on. To interrupt sophisticated computations by empirical handlings is like interrupting a flight by several walks.

1.3.3. CFA transfers a naturalistic way of investigation into a statistical space

Most of the time, this way of investigation is accepted because the statistical investigation plays a subordinate part in vegetation science, when CFA brings only graphical displays and details and keeps the leading part to the visual examination of floristical tables. Since the number of species is large, a graph shows a little part of the initial distances, generally less than 20% of the dispersion, as if the graph was taking into account only 20% of the data. The graph of a subset of relevés shows their main gradient and explains it indirectly, according to the positions of previously identified community-types along the factor axis. In short, it transfers into the statistical graph the naturalistic way of investigation during field work.

1.3.4. How to adjust the ecological basis of the naturalistic method with the objectivity of CFA?

1) On the one hand, the classical method has an ecological basis. It studies the visual structure of plants and relevés in the tables of initial data and it takes into account the ecological confinings of species, expressed by their fidelities to the community-types of the phytosociological hierarchy. But a visual investigation cannot be objective and accurate. Moreover, it tends to give a practical priority to the constancy, which is less important but more visible on a table than the fidelity. 2) On the other hand, CFA is objective, free from preconceived groupings, but it is based only on the numbers of species shared with the relevés, so it lacks an ecological basis.

It is possible to adjust the advantages of both ways of investigation. 1) If we locate the plants and the relevés in the space defined by the fidelities of plants to plants, rather than the fidelities of plants to relevés. 2) If we determine the types of plant community through a classification, which often expresses 80% of the initial dispersion, instead of a visual partition of a graphical ordination, which often expresses only 20% of the dispersion.

2. Application to the classification of 384 relevés at the scale of a district

2.1. *Scheme of the classification* (Fig. 1)

The first example of an ecological classification of floristical relevés deals with 384 relevés which have been sampled in a district of the Northern Vosges (Müller, 1986). The relevés include 322 vascular species whose the most frequent are split into two or three classes of abundance and generate 480 plants with abundance threshold. Then the relevés are characterized by their average fidelities to the 5.626 plants of the national data bank and localized in national gradients. They are classified into hierarchical groupings, at several levels of synthesis.

2.2. *The levels of synthesis*

2.2.1. The upper levels

The first level shows three groupings having rather similar effectives: 196,

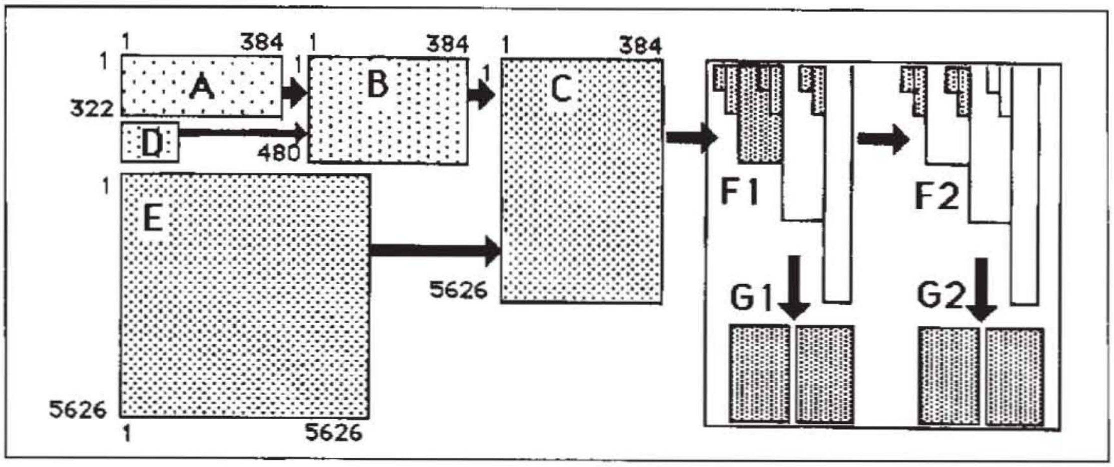

Figure 1.– Classification of a set of relevés: Scheme of the method. A. Table of abundance for 322 species in 384 relevés. B. Table of presence for 480 plants with abundance thresholds in 384 relevés. C. Table of average fidelities of 384 relevés to 5626 plants of the bank. D. Thresholds of abundance for the plants of the bank. E. Table of fidelities of plants to plants in the bank. F1 and F2. Dendrogram of the relevés at the levels of synthesis 1 and 2. G1 and G2. Table of discriminant plants for the groupings at the levels 1 and 2. On the right, the rectangular outline including F and G is the scheme of Figures 2 to 9 which illustrate the examples of classification and which are shifted after the text.

108 and 80 relevés (Fig. 2). The author of the observations assigns the relevés of the 1st grouping 195 to 5 different phytosociological classes, and those of the 2nd grouping 302 to 3 classes. So, a classification is able to discriminate groupings which have a hierarchical level above the phytosociological classes and consequently which have the highest differences and effectives. A classification does not need a previous splitting of the relevés into the main types.

2.2.2. The lower levels

The automatic classification divides the same dendrogram of the relevés at successive levels of synthesis. From the widest to the most detailed, it shows more and more detailed sub-groupings, corresponding to larger and larger scales, from the 2nd level (Fig. 3) to the 3rd and 4th level of synthesis (Fig. 4 and 6).

The lower levels identify a peculiar grouping, even if it has a few relevés. The 3 sub-groupings of the grouping 302 have respectively 57, 48 et 3 relevés (Fig. 3). The grouping having 3 relevés has 5 discriminant plants coming from around ponds, as the two other sub-groupings have discriminant plants coming from peat-bogs and swamps.

LES DONNEES CONCERNENT 384 RELEVES, 480 PLANTES CARACTERISEES PAR LEURS FIDELITES A 5626 PLANTES

NIVEAU DE SYNTHESE NUMERO 1

DENDROGRAMME DES RELEVES	NO SUR LE DENDRO	NUMERO DES GROUPES RETENUS	EFFECTIFS DES REL	PLA	OBS	OBS/PLA	OBS/REL
I==I - - - - - - - - - - - - - - - -	195	1	196	393	6222	15.8	31.7
I=I- - - - - - - - - - - - - - - - -	302	2	108	115	1213	10.5	11.2
I	303						
I=I- - - - - - - - - - - - - - - - -	382	3	80	116	1342	11.6	16.8
I	383		384	480	8777		

LISTE DES PLANTES DISCRIMINANTES DES GROUPES DE RELEVES

NUM	NOM DES PLANTES		GPMENT 195 DIS	FID	CST	GPMENT 302 DIS	FID	CST	GPMENT 382 DIS	FID	CST
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 195											
2541	LOTUS CORNICULATUS L.	1-6	**32**	100	22	-17	0	0	-5	0	0
2788	PLANTAGO LANCEOLATA L.	1-5	**30**	100	35	-13	0	0	-8	0	0
686	ACHILLEA MILLEFOLIUM L.	1-5	**24**	100	36	-13	0	0	-4	0	0
1073	HIERACIUM PILOSELLA L.	1-6	**23**	100	55	-13	0	0	-4	0	0
2141	THYMUS SERPYLLUM L.	1-6	**22**	100	40	-13	0	0	-3	0	0
4610	AGROSTIS VULGARIS WITH.	1-6	**22**	82	58	-16	0	0	-1	16	28
4819	FESTUCA OVINA L.	1-6	**21**	80	75	-14	1	2	-2	17	41
4652	ANTHOXANTHUM ODORATUM L	1-6	**17**	93	29	-9	0	0	-2	6	5
4688	BRACHYPODIUM PINNATUM (	1-6	**14**	100	2	-11	0	0	0	0	0
2691	TRIFOLIUM PRATENSE L.	1-6	**13**	100	13	-5	0	0	-4	0	0
4763	DACTYLIS GLOMERATA L.	1-6	**13**	95	11	-9	0	0	-1	4	1
4699	BRIZA MEDIA L.	1-5	**12**	100	15	-3	0	0	-5	0	0
3411	SANGUISORBA MINOR SCOP.	1-6	**11**	100	1	-6	0	0	-1	0	0
4708	BROMUS ERECTUS HUDS.	1-6	**11**	100	6	-6	0	0	-2	0	0
2919	RUMEX ACETOSELLA L.	1-6	**9**	98	52	-5	0	0	-1	1	2
1096	HYPOCHOERIS RADICATA L.	1-5	**9**	100	33	-4	0	0	-2	0	0
888	CHRYSANTHEMUM LEUCANTHE	1-5	**9**	100	9	-5	0	0	-1	0	0
2694	TRIFOLIUM REPENS L.	1-6	**9**	100	19	-3	0	0	-3	0	0
2787	PLANTAGO LANCEOLATA L.	2-5	**8**	100	20	-3	0	0	-2	0	0
4868	HOLCUS LANATUS L.	1-6	**8**	100	18	-1	0	0	-5	0	0
2540	LOTUS CORNICULATUS L.	2-6	**8**	100	8	-4	0	0	-1	0	0
3130	RANUNCULUS BULBOSUS L.	1-6	**8**	100	18	-3	0	0	-1	0	0
1962	HYPERICUM PERFORATUM L.	1-4	**7**	100	26	-4	0	0	0	0	0
2140	THYMUS SERPYLLUM L.	2-6	**7**	100	27	-3	0	0	-1	0	0
4402	CAREX GLAUCA MURR.	1-5	**6**	100	1	-4	0	0	0	0	0
1072	HIERACIUM PILOSELLA L.	2-6	**6**	100	31	-3	0	0	-1	0	0
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 302											
4927	MOLINIA CAERULEA (L.) M	1-6	-39	38	43	**62**	38	78	-1	22	62
4511	ERIOPHORUM ANGUSTIFOLIU	1-6	-19	0	0	**46**	98	70	-6	1	1
1665	DROSERA ROTUNDIFOLIA L.	1-4	-7	0	0	**18**	100	33	-2	0	0
4336	CAREX AMPULLACEA GOOD.	1-6	-7	0	0	**17**	100	33	-2	0	0
5137	JUNCUS SILVATICUS (REIC	1-6	-2	18	2	**13**	81	20	-4	0	0
4518	RHYNCHOSPORA ALBA (L.)	1-5	-4	0	0	**11**	100	33	-1	0	0
4404	CAREX GOODENOUGHI GAY	1-6	-3	0	0	**10**	100	2	-1	0	0
2231	MENYANTHES TRIFOLIATA L	1-6	-3	0	0	**9**	100	6	-1	0	0
3247	COMARUM PALUSTRE L.	1-6	-3	0	0	**9**	100	19	-1	0	0
1706	ERICA TETRALIX L.	1-6	-3	0	0	**8**	0	0	-1	0	0
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 382											
1786	FAGUS SILVATICA L.	1-6	-9	20	4	-11	0	0	**69**	80	45
4771	DESCHAMPSIA FLEXUOSA (L	1-6	-5	25	12	-15	0	0	**62**	74	88
1801	QUERCUS SESSILIFLORA SA	1-6	-5	15	5	-8	0	0	**42**	84	68

Figure 2 – The 3 community-types of the first level of synthesis (Vosges). Above: the dendrogram of the types. REL = Relevés. PLA = Plants. OBS = Observations. OBS/PLA = Average frequency of the plant in the type. OBS/REL = Average effective of the plants in the relevés of the type. Below: the list of the discriminant plants. One line of the list shows: 1) the number of the plant; 2) the latin name of the taxon; 3) the lower and upper thresholds of the abundance; 4) the values of three parameters for each grouping. DIS† = Discriminant power. FID = Fidelity. CST = Constancy.

1801	QUERCUS SESSILIFLORA SA	1-6	-5	15	5	-8	0	0	**42**	84	68
1716	VACCINIUM MYRTILLUS L.	1-6	-9	20	10	-3	9	8	**38**	70	86
3420	SORBUS AUCUPARIA L.	1-6	-6	16	4	-3	0	0	**32**	83	57
5563	PTERIDIUM AQUILINUM (L.	1-6	-1	50	26	-10	1	1	**31**	47	60
259	LONICERA PERICLYMENUM L	1-6	-3	0	0	-4	0	0	**25**	0	0
1797	QUERCUS PEDUNCULATA EHR	1-6	-2	14	3	-3	0	0	**21**	85	43
4770	DESCHAMPSIA FLEXUOSA (L	3-6	-2	0	0	-3	0	0	**19**	100	8
2135	TEUCRIUM SCORODONIA L.	1-6	0	47	11	-9	0	0	**17**	52	30
1327	CORYLUS AVELLANA L.	1-6	0	0	0	-5	0	0	**16**	0	0

Figure 2 – *(cont.)*

NIVEAU DE SYNTHESE NUMERO 2

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        DENDROGRAMME DES RELEVES   NO      NUMERO     EFFECTIFS DES
                                  SUR LE    DES       REL  PLA  OBS   OBS/PLA   OBS/RE
                                  DENDRO   GROUPES
                                           RETENUS
     I- - - - - - - - - - - - -    150       1        151  332 3781    11.4     25.0
     I=====I - - - - - - - - -    194       2         45  197 2441    12.4     54.2
  I==I                             195
  I    I- - - - - - - - - - - -    251       3         57   70  614     8.8     10.8
  I    II - - - - - - - - - - -    298       4         48   69  583     8.4     12.1
  I I==I                           299
  I I=========I - - - - - - - -    301       5          3    8   16     2.0      5.3
  I=I                              302
  I                                303
  I         II - - - - - - - - -   367       6         65   98 1075    11.0     16.5
  I         I===I- - - - - - - -   379       7         13   34  241     7.1     18.5
  I      I=I                       380
  I I====I                         381
  I=I                              382
  I                                383
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LISTE DES PLANTES DISCRIMINANTES DES GROUPES DE RELEVES

NUM	NOM DES PLANTES		GPMENT 150 DIS	FID	CST	GPMENT 194 DIS	FID	CST
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 150								
4819	FESTUCA OVINA L.	1-6	**33**	59	72	8	20	84
4610	AGROSTIS VULGARIS WITH.	1-6	**33**	51	47	9	30	95
1073	HIERACIUM PILOSELLA L.	1-6	**24**	61	44	16	38	93
2919	RUMEX ACETOSELLA L.	1-6	**23**	68	47	1	29	68
4688	BRACHYPODIUM PINNATUM (	1-6	**12**	100	2	11	0	0
1096	HYPOCHOERIS RADICATA L.	1-5	**11**	62	27	6	37	55
4766	DANTHONIA DECUMBENS (L.	1-5	**10**	67	43	0	29	62
2107	STACHYS OFFICINALIS (L.	1-4	**10**	80	32	0	9	13
2478	GENISTA PILOSA L.	1-6	**9**	79	43	0	8	15
205	JASIONE MONTANA L.	1-6	**7**	81	19	0	18	15
1962	HYPERICUM PERFORATUM L.	1-4	**7**	61	21	5	38	44
2638	SAROTHAMNUS SCOPARIUS (	1-6	**7**	55	35	0	26	57
1072	HIERACIUM PILOSELLA L.	2-6	**6**	50	20	5	49	66
4821	VAR. TENUIFOLIA DUBY	1-6	**5**	42	21	1	50	84
4818	FESTUCA OVINA L.	3-6	**5**	42	7	2	57	33
2116	TEUCRIUM CHAMAEDRYS L.	1-5	**4**	0	0	2	0	0
2918	RUMEX ACETOSELLA L.	2-6	**4**	60	21	0	39	46

Figure 3 – The community-types of the second level of synthesis (Vosges). Same legend as figure 2.

PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 194									
2788	PLANTAGO LANCEOLATA L.	1-5	15	35	16	**40**	64	100
2541	LOTUS CORNICULATUS L.	1-6	17	20	5	**40**	79	77
686	ACHILLEA MILLEFOLIUM L.	1-5	13	39	18	**29**	60	95
2691	TRIFOLIUM PRATENSE L.	1-6	3	0	0	**26**	100	57
2141	THYMUS SERPYLLUM L.	1-6	16	45	23	**22**	55	97
4763	DACTYLIS GLOMERATA L.	1-6	5	47	7	**20**	47	24
4652	ANTHOXANTHUM ODORATUM L	1-6	11	27	11	**18**	65	88
4699	BRIZA MEDIA L.	1-5	4	3	0	**18**	96	64
888	CHRYSANTHEMUM LEUCANTHE	1-5	2	0	0	**17**	100	42
2787	PLANTAGO LANCEOLATA L.	2-5	1	14	3	**16**	85	77
3130	RANUNCULUS BULBOSUS L.	1-6	1	8	1	**15**	91	75
2694	TRIFOLIUM REPENS L.	1-6	3	28	7	**14**	71	60
4708	BROMUS ERECTUS HUDS.	1-6	5	8	0	**14**	91	24
3411	SANGUISORBA MINOR SCOP.	1-6	6	0	0	**13**	100	4
2540	LOTUS CORNICULATUS L.	2-6	2	0	0	**12**	100	37
4868	HOLCUS LANATUS L.	1-6	3	22	5	**12**	77	62
4989	POA PRATENSIS L.	1-5	0	9	1	**12**	90	66
1139	LEONTODON HISPIDUS L.	1-5	1	0	0	**11**	100	55
2917	RUMEX ACETOSA L.	1-5	1	27	5	**9**	72	46
685	ACHILLEA MILLEFOLIUM L.	2-5	1	9	2	**9**	90	84
2690	TRIFOLIUM PRATENSE L.	2-6	0	0	0	**9**	100	31

LISTE DES PLANTES DISCRIMINANTES DES GROUPES DE RELEVES

NUM	NOM DES PLANTES		GPMENT **251**			GPMENT **298**			GPMENT **301**		
			DIS	FID	CST	DIS	FID	CST	DIS	FID	CST
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 251											
4511	ERIOPHORUM ANGUSTIFOLIU	1-6	**46**	61	82	34	37	60	0	0	0
4336	CAREX AMPULLACEA GOOD.	1-6	**25**	97	61	3	2	2	0	0	0
3247	COMARUM PALUSTRE L.	1-6	**14**	100	36	1	0	0	0	0	0
2231	MENYANTHES TRIFOLIATA L	1-6	**13**	100	12	2	0	0	0	0	0
5137	JUNCUS SILVATICUS (REIC	1-6	**12**	48	22	9	33	18	3	0	0
4420	CAREX LASIOCARPA EHRH.	1-6	**11**	94	57	0	5	4	0	0	0
4518	RHYNCHOSPORA ALBA (L.)	1-5	**10**	55	35	8	44	33	0	0	0
4392	CAREX FLAVA L.	1-5	**10**	50	19	0	0	0	3	0	0
4596	AGROSTIS CANINA L.	1-6	**9**	19	35	1	2	6	2	0	0
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 298											
4927	MOLINIA CAERULEA (L.) M	1-6	31	16	63	**116**	21	100	3	0	33
1687	CALLUNA VULGARIS (L.) H	1-6	-12	0	1	**54**	19	95	-26	0	0
1665	DROSERA ROTUNDIFOLIA L.	1-4	6	22	14	**44**	77	58	0	0	0
3340	POTENTILLA TORMENTILLA	1-6	0	0	1	**28**	15	37	-9	0	0
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 301											
4550	SCIRPUS MULTICAULIS SM.	1-6	8	81	31	0	4	2	**87**	13	100
5144	JUNCUS SUPINUS MOENCH	1-6	12	62	38	0	11	8	**61**	8	100
4549	SCIRPUS MULTICAULIS SM.	3-6	1	40	3	0	0	0	**40**	60	100
3136	RANUNCULUS FLAMMULA L.	1-6	3	0	0	0	0	0	**27**	0	0
1979	HYDROCOTYLE VULGARIS L.	1-6	6	100	10	0	0	0	**23**	0	0

LISTE DES PLANTES DISCRIMINANTES DES GROUPES DE RELEVES

NUM	NOM DES PLANTES		GPMENT **367**			GPMENT **379**		
			DIS	FID	CST	DIS	FID	CST
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 367								
1786	FAGUS SILVATICA L.	1-6	**70**	75	52	45	2	7
4771	DESCHAMPSIA FLEXUOSA (L	1-6	**68**	65	95	31	8	61
1801	QUERCUS SESSILIFLORA SA	1-6	**50**	80	80	10	1	7
5563	PTERIDIUM AQUILINUM (L.	1-6	**35**	43	67	13	3	30
259	LONICERA PERICLYMENUM L	1-6	**26**	0	0	16	0	0
2135	TEUCRIUM SCORODONIA L.	1-6	**22**	52	36	2	0	0
4770	DESCHAMPSIA FLEXUOSA (L	3-6	**21**	100	10	8	0	0
1327	CORYLUS AVELLANA L.	1-6	**17**	0	0	8	0	0

Figure 3 – *(cont.)*.

PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 379

5523	POLYSTICHUM SPINULOSUM	1-5	3	6	1	**56**	86	100
1716	VACCINIUM MYRTILLUS L.	1-6	34	56	84	**49**	13	100
3420	SORBUS AUCUPARIA L.	1-6	28	60	50	**41**	21	92
5527	SUBSP. SPINULOSUM MU	1-5	1	7	1	**26**	92	100
5522	POLYSTICHUM SPINULOSUM	2-5	0	0	0	**23**	100	84
1797	QUERCUS PEDUNCULATA EHR	1-6	20	63	40	**22**	21	69
5556	ATHYRIUM FILIX-FEMINA (	1-6	3	0	0	**19**	50	7
2327	OXALIS ACETOSELLA L.	1-6	5	0	0	**18**	0	0
3212	RHAMNUS FRANGULA L.	1-6	11	27	55	**15**	9	92

Figure 3 – *(cont.)*.

NIVEAU DE SYNTHESE NUMERO 3

```
      DENDROGRAMME DES RELEVES     NO      NUMERO     EFFECTIFS DES
                                   SUR LE  DES        REL  PLA  OBS   OBS/PLA   OBS/REL
                                   DENDRO  GROUPES
                                           RETENUS
        I - - - - - - - - - - -     74       1         75  103 1543    15.0      20.6
        I - - - - - - - - - - -    100       2         27  183 1049     5.7      38.9
      I=I                          101
      I===I - - - - - - - - - -    111       3         11   91  397     4.4      36.1
   I==I                            112
   I====I - - - - - - - - - - -    129       4         18   74  403     5.4      22.4
   I                               130
   I==I - - - - - - - - - - - -    149       5         20   82  389     4.7      19.4
   I                               150
   I      II- - - - - - - - - -    183       6         34  178 1875    10.5      55.1
   I      I=====I - - - - - - -    193       7         11  119  566     4.8      51.5
   I======I                        194
I==I                               195
I     I==I- - - - - - - - - - -    227       8         33   54  356     6.6      10.8
I     II- - - - - - - - - - - -    249       9         23   39  254     6.5      11.0
I    II                            250
I    I                             251
I    II=I - - - - - - - - - - -    282      10         32   61  437     7.2      13.7
I    II======I - - - - - - - - -   297      11         16   30  146     4.9       9.1
I    II                            298
I I==I                             299
I I==========I                     301
I=I                                302
I                                  303
I         I=I - - - - - - - - -    356      12         54   70  730    10.4      13.5
I         I==I- - - - - - - - -    366      13         11   76  345     4.5      31.4
I       II                         367
I       I   I==I - - - - - - -     376      14         10   31  189     6.1      18.9
I       I   I===I- - - - - - -     378      15          3   23   52     2.3      17.3
I       I===I                      379
I     I-I                          380
I I=====I                          381
I=I                                382
I                                  383
```

Figure 4 – Dendrogram of the community-types of the third level of synthesis (Vosges). Same legend as figure 2 (above).

LISTE DES PLANTES DISCRIMINANTES DES GROUPES DE RELEVES

NUM	NOM DES PLANTES		GPMENT 74			GPMENT 100			GPMENT 111			GPMENT 129			GPMENT 149		
			DIS	FID	CST	DIS	FID	CST	DIS	FID	CST	DIS	FID	CST	DIS	FID	CST
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 74																	
4819	FESTUCA OVINA L.	1-6	41	34	84	2	10	74	13	4	81	24	8	83	-3	1	15
2478	GENISTA PILOSA L.	1-6	31	68	74	0	4	14	0	3	27	0	0	0	-2	2	10
1073	HIERACIUM PILOSELLA L.	1-6	31	41	60	2	5	22	0	3	36	24	11	66	-2	0	0
1687	CALLUNA VULGARIS (L.) H	1-6	29	29	92	-6	6	55	12	4	100	-6	0	11	-14	4	55
2107	STACHYS OFFICINALIS (L.	1-4	25	59	48	9	21	48	1	0	0	-1	0	0	-2	0	0
2116	TEUCRIUM CHAMAEDRYS L.	1-5	11	0	0	4	0	0	-2	0	0	0	0	0	-1	0	0
1686	CALLUNA VULGARIS (L.) H	4-6	11	62	49	0	0	0	1	6	36	0	0	0	-2	0	0
4207	VIOLA CANINA L.	1-4	9	48	57	1	19	62	1	4	36	0	0	0	0	2	10
4402	CAREX GLAUCA MURR.	1-5	9	0	0	7	100	11	0	0	0	0	0	0	0	0	0
195	CAMPANULA ROTUNDIFOLIA	1-6	9	10	4	3	39	40	0	7	18	0	0	0	-1	0	0
2638	SAROTHAMNUS SCOPARIUS (	1-6	9	17	22	8	26	96	0	2	18	3	9	50	-3	0	0
5452	JUNIPERUS COMMUNIS L.	1-6	9	0	0	1	0	0	-1	0	0	0	0	0	-3	0	0
2494	HIPPOCREPIS COMOSA L.	1-5	7	0	0	2	0	0	-1	0	0	0	0	0	-1	0	0
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 100																	
4763	DACTYLIS GLOMERATA L.	1-6	0	0	0	24	47	40	0	0	0	1	0	0	0	0	0
4688	BRACHYPODIUM PINNATUM (	1-6	21	0	0	21	100	14	-1	0	0	0	0	0	-2	0	0
1327	CORYLUS AVELLANA L.	1-6	0	0	0	17	0	0	-2	0	0	-5	0	0	-7	0	0
41	HEDERA HELIX L.	1-6	0	0	0	17	0	0	-2	0	0	-3	0	0	-6	0	0
2135	TEUCRIUM SCORODONIA L.	1-6	6	13	8	16	34	59	0	0	0	-2	0	0	-11	0	0
3253	CRATAEGUS MONOGYNA JACQ	1-6	1	0	0	16	57	14	-1	0	0	0	0	0	-3	0	0
686	ACHILLEA MILLEFOLIUM L.	1-5	2	1	1	15	21	55	3	5	36	8	4	16	0	7	25
3269	FRAGARIA VESCA L.	1-6	0	0	0	14	83	55	0	0	0	0	0	0	-1	0	0
2541	LOTUS CORNICULATUS L.	1-6	10	0	0	11	4	7	1	0	0	5	0	0	0	15	35
1733	EUPHORBIA CYPARISSIAS L	1-5	3	1	1	10	35	96	-1	0	0	3	8	33	-1	0	0
272	CARPINUS BETULUS L.	1-6	0	0	0	10	47	37	-1	0	0	-3	0	0	-5	0	0
1962	HYPERICUM PERFORATUM L.	1-4	2	11	8	9	28	55	0	5	27	4	5	16	0	9	25
3479	GALIUM MOLLUGO L.	1-6	0	0	0	9	35	18	0	0	0	0	0	0	0	0	0
1263	SOLIDAGO VIRGA-AUREA L.	1-4	4	54	16	7	22	18	0	4	9	-1	0	0	-5	0	0
4708	BROMUS ERECTUS HUDS.	1-6	6	0	0	7	0	0	-1	0	0	2	8	5	-1	0	0
3411	SANGUISORBA MINOR SCOP.	1-6	5	0	0	7	0	0	0	0	0	4	0	0	0	0	0
1325	CORNUS SANGUINEA L.	1-6	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
3362	PRUNUS SPINOSA L.	1-6	1	0	0	7	0	0	0	0	0	0	0	0	0	0	0
1786	FAGUS SILVATICA L.	1-6	-3	0	0	6	20	33	-7	0	0	-15	0	0	-19	0	0
4870	HOLCUS MOLLIS L.	1-6	0	1	1	6	23	55	0	0	0	0	0	0	-1	0	0
259	LONICERA PERICLYMENUM L	1-6	0	0	0	6	0	0	0	0	0	-7	0	0	-10	0	0
1801	QUERCUS SESSILIFLORA SA	1-6	0	1	1	6	13	33	-3	0	0	-9	0	0	-15	0	0
4986	POA NEMORALIS L.	1-6	0	0	0	6	0	0	0	0	0	0	0	0	-1	0	0
4236	VIOLA RIVINIANA RCHB.	1-5	0	0	0	6	60	51	0	0	0	0	0	0	-1	0	0
4103	PIMPINELLA SAXIFRAGA (L	1-4	2	0	0	5	29	33	0	0	0	0	0	0	0	0	0
3836	VERONICA CHAMAEDRYS L.	1-4	0	0	0	5	31	33	0	0	0	0	0	0	0	0	0
4762	DACTYLIS GLOMERATA L.	2-6	0	0	0	5	66	7	0	0	0	0	0	0	0	0	0
3054	ANEMONE NEMOROSA L.	1-6	0	0	0	5	36	33	0	0	0	-2	0	0	-3	0	0
1064	HIERACIUM MURORUM L.	1-6	2	0	0	5	50	11	-1	0	0	0	0	0	-4	0	0
3851	VERONICA OFFICINALIS L.	1-6	2	2	1	5	37	51	1	8	27	0	0	0	-1	0	0
4654	ARRHENATHERUM ELATIUS (	1-6	0	0	0	5	26	22	0	0	0	0	8	11	0	0	0
4695	BRACHYPODIUM SILVATICUM	1-6	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
858	CENTAUREA NIGRA L.	1-4	0	0	0	4	72	48	3	11	18	0	0	0	0	0	0
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 111																	
3340	POTENTILLA TORMENTILLA	1-6	20	43	65	-5	11	48	77	8	90	-12	0	0	0	6	35
5156	LUZULA CAMPESTRIS L.	1-5	2	0	0	0	12	33	58	14	90	2	8	33	0	0	0
3339	POTENTILLA TORMENTILLA	2-6	15	48	29	-1	6	11	47	22	90	-2	0	0	0	0	0
4652	ANTHOXANTHUM ODORATUM L	1-6	4	0	0	5	4	11	44	8	45	4	14	50	0	0	0
4868	HOLCUS LANATUS L.	1-6	0	0	0	0	0	0	37	22	72	0	0	0	2	0	0
1658	SUCCISA PRAEMORSA (GILI	1-6	10	56	40	0	3	7	28	16	81	-2	0	0	0	0	0
4766	DANTHONIA DECUMBENS (L.	1-5	22	46	60	0	6	22	27	10	90	0	3	16	0	1	5
4610	AGROSTIS VULGARIS WITH.	1-6	11	5	10	8	19	100	27	7	90	17	10	77	4	9	65
5158	SUBSP. ERECTA DESV.	1-5	0	0	0	0	30	25	25	43	90	0	0	0	0	0	0
4830	FESTUCA RUBRA L.	1-6	1	0	0	0	0	0	22	0	0	0	0	0	0	0	0
4932	NARDUS STRICTA L.	1-6	6	55	33	-1	0	0	20	20	81	0	0	0	0	4	10
5155	LUZULA CAMPESTRIS L.	2-5	0	0	0	0	4	7	19	14	54	0	2	5	0	0	0
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 129																	
2919	RUMEX ACETOSELLA L.	1-6	8	39	54	0	3	14	1	5	54	60	16	94	3	2	15
205	JASIONE MONTANA L.	1-6	4	40	20	0	0	0	0	0	0	30	40	83	0	0	0
1607	TEESDALEA NUDICAULIS (L	1-4	0	5	1	0	0	0	0	0	0	27	94	94	0	0	0
2141	THYMUS SERPYLLUM L.	1-6	18	17	18	5	7	22	0	1	9	20	18	83	-3	0	0
2918	RUMEX ACETOSELLA L.	2-6	2	32	22	0	1	3	0	5	27	19	20	61	0	0	0
1096	HYPOCHOERIS RADICATA L.	1-5	2	28	25	0	0	0	9	15	90	18	12	44	2	6	20
2788	PLANTAGO LANCEOLATA L.	1-5	0	1	1	5	1	3	10	8	54	17	8	33	11	15	55

Figure 5 – List of the discriminant plants for the sub-groups of the upper group 150 (Vosges) at the third level. Same legend as figure 2.

463	SCLERANTHUS PERENNIS L.	1-5	0	5	1	0	0	0	0	0	0	16	94	100	0	0	0
4751	CORYNEPHORUS CANESCENS	1-5	2	50	24	0	0	0	0	0	0	14	50	100	0	0	0
4618	AIRA PROECOX L.	1-5	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0
2627	ORNITHOPUS PERPUSILLUS	1-6	0	0	0	0	0	0	0	0	0	13	12	5	1	12	5
1002	FILAGO MINIMA (SM.) PER	1-5	0	0	0	0	0	0	0	0	0	13	71	27	0	28	10
1606	TEESDALEA NUDICAULIS (L	2-4	0	0	0	0	0	0	0	0	0	10	100	50	0	0	0
PLANTES DISCRIMINANTES DU GROUPEMENT NUMERO 149																	
5108	JUNCUS BUFONIUS L.	1-6	0	0	0	0	0	0	0	0	0	0	0	0	55	100	85
1952	HYPERICUM HUMIFUSUM L.	1-3	0	0	0	0	0	0	0	0	0	0	0	0	21	100	80
2000	BRUNELLA VULGARIS L.	1-4	0	0	0	0	5	3	2	15	27	0	0	0	18	68	65
4969	POA ANNUA L.	1-6	0	0	0	0	0	0	0	0	0	0	0	0	18	100	10
2890	POLYGONUM AVICULARE L.	1-5	0	0	0	0	0	0	0	0	0	0	0	0	17	100	10
1019	GNAPHALIUM ULIGINOSUM L	1-5	0	0	0	0	0	0	0	0	0	0	0	0	17	100	45
5107	JUNCUS BUFONIUS L.	2-6	0	0	0	0	0	0	0	0	0	0	0	0	15	100	40
5126	JUNCUS LAMPROCARPUS (EH	1-6	0	0	0	0	0	0	0	0	0	0	0	0	12	100	40
2790	PLANTAGO MAJOR L.	1-5	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0
2694	TRIFOLIUM REPENS L.	1-6	0	0	0	0	0	0	7	13	45	1	0	0	12	15	30
2953	ANAGALLIS ARVENSIS L.	1-4	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0
2199	RADIOLA LINOIDES ROTH	1-4	0	0	0	0	0	0	0	0	0	0	0	0	11	100	75
4392	CAREX FLAVA L.	1-5	-5	0	0	-4	0	0	0	0	0	-1	0	0	11	50	55
4396	SUBSP. OEDERI RETZ.	1-5	-3	0	0	-2	0	0	0	0	0	0	0	0	8	50	55
3167	RANUNCULUS REPENS L.	1-6	-1	0	0	0	0	0	2	0	0	0	0	0	8	100	5
2051	MENTHA ARVENSIS L.	1-5	0	0	0	0	0	0	0	0	0	0	0	0	7	100	50
4591	AGROSTIS ALBA L.	1-6	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0

Figure 5 – *(cont.)*

```
NIVEAU  DE  SYNTHESE  NUMERO       4
        DENDROGRAMME DES RELEVES        NO   NUMERO       EFFECTIFS DES
                                     SUR LE   DES        REL  PLA  OBS  OBS/PLA  OBS/REL
                                     DENDRO GROUPES
                                            RETENUS
           I- - - - - - - - - - - -     55      1         56   87 1293   14.9     23.1
           II - - - - - - - - - - -     73      2         19   45  250    5.6     13.2
           I                            74
           I=I- - - - - - - - - - -     91      3         18  160  834    5.2     46.3
           II - - - - - - - - - - -     99      4          9   72  215    3.0     23.9
           I                           100
         I=I                           101
         I===I                         111
      I==I                             112
      I    I=I- - - - - - - - - - -    121      5         10   29  129    4.4     12.9
      I    I======I - - - - - - - -    128      6          8   73  274    3.8     34.3
      I====I                           129
      I                                130
      I  I==I - - - - - - - - - - -    145      7         16   73  317    4.3     19.8
      I  I=I- - - - - - - - - - - -    148      8          4   35   72    2.1     18.0
      I==I                             149
      I                                150
      I         I=I- - - - - - - - -   172      9         23  161 1291    8.0     56.1
      I         I===I- - - - - - - -   181     10         10  117  547    4.7     54.7
      I        II                      182
      I       II                       183
      I       I     I- - - - - - - -   188     11          6  106  307    2.9     51.2
      I       I     I- - - - - - - -   192     12          5   93  259    2.8     51.8
      I       I=====I                  193
      I=======I                        194
   I==I                                195
   I           II- - - - - - - - - -   212     13         18   30  169    5.6      9.4
   I           I=I - - - - - - - - -   217     14          6   26   76    2.9     12.7
   I          II                       218
   I          II - - - - - - - - - -   221     15          4   16   40    2.5     10.0
```

Figure 6 – Dendrogram of the community-types of the fourth level of synthesis (Vosges). Same legend as figure 2 (above).

```
I        II                                     222
I        I                                      223
I        I=I - - - - - - - - - - -              226      16       4   23   54    2.3    13.5
I      I==I                                     227
I      I    II- - - - - - - - - - -             237      17      11   24  103    4.3     9.4
I      I    II- - - - - - - - - - -             246      18      10   33  144    4.4    14.4
I      II===I                                   247
I      II                                       249
I     II                                        250
I     I                                         251
I     I  I- - - - - - - - - - - - -             273      19      23   54  340    6.3    14.8
I     I  I==I - - - - - - - - - - -             281      20       9   19   97    5.1    10.8
I     II=I                                      282
I     II      I=I- - - - - - - - -              292      21      11   18  100    5.6     9.1
I     II      II - - - - - - - - - -            296      22       5   20   46    2.3     9.2
I     II=====I                                  297
I     II                                        298
I I==I                                          299
I I=========I                                   301
I=I                                             302
I                                               303
I             I=I- - - - - - - - -              332      23      30   50  501   10.0    16.7
I             II - - - - - - - - - -            351      24      20   25  145    5.8     7.3
I             I                                 352
I             I==I - - - - - - - - -            355      25       4   38   84    2.2    21.0
I          I=I                                  356
I          I        II - - - - - - -            358      26       3   48   92    1.9    30.7
I          I        I===I- - - - - -            360      27       3   46  103    2.2    34.3
I          I        II                          361
I          I      II                            362
I          I==I                                 366
I          II                                   367
I          I    I==I                            376
I          I    I===I                           378
I          I===I                                379
I       I=I                                     380
I I=====I                                       381
I=I                                             382
I                                               383
```

Figure 6 – *(Cont.)*

3. Characterization of the community-types by their discriminant plants

3.1. *Determination of the discriminant plants*

3.1.1. The discriminant plants characterize the peculiarity of a community-type

They are the plants which contribute, for a half, to the distance between the grouping and the whole relevés. They reflect the ecology and the physiognomy of the community-type. On the 1st level of synthesis, they come respectively from meadows, peat-bogs and mesophilous forests. At the 2nd level, among the meadows, they are mostly acidophilous, for the sub-group 150, and mesophilous for the other; for the 3 subdivisions of peat-bogs, they come respectively from swamps, peat-bogs with *Drosera,* and from the borders of ponds; for the 2 subdivisions of the forests, they are rather acidophilous or slightly hydrophilous.

3.1.2. Moderate effective of the discriminant plants

At the first level of synthesis, the 3 community-types have respectively 25, 10 and 11 discriminant plants. Together, these 46 plants contribute at least to half the distance between the grouping and the centre of gravity of the 384 relevés, in the space of fidelities. Among 5.626 plants of the bank, 10 to 25 plants are enough to characterize half the peculiarity of a grouping. If there are few discriminant plants for a grouping, they have high DIS, and vice-versa. For the 1st grouping 195, there are 25 discriminant plants having low DIS, between 6 and 32 per 1.000, as for the 3rd grouping 382, there are only 10 plants having DIS between 16 and 69 per 1.000 (Fig. 2). Along the successive levels of synthesis, the discriminant plants still have moderate effectives (Fig. 4 to 6).

3.1.3. The discriminant power DIS reflects indirectly the variation of the constancy CST and of the fidelity FID

The table shows the discriminant plants in order according to the decreasing values of DIS. The table shows also, as a comparative documentation, two classical parameters, the fidelity FID and the constancy CST, for each plant in respect to the grouping. Most of the discriminant plants of the 1st grouping 195 have a fidelity of 100% to it, half of them for the 2nd grouping 302 and only one for the 3rd grouping 382. Among the groupings of a same level, the DIS of a plant often increases or decreases together with the fidelity or the constancy or both. However, DIS is not a function of the two parameters. DIS comes from the fidelity of the grouping to the plant, opposite to the classical parameter FID, which is the fidelity of the plant to the grouping. DIS depend on all the plants of the grouping, whereas FID depends only on the distribution of a single plant. DIS has a global meaning about the community-type.

3.2. *Discriminant plants may be absent from the community-type*

3.2.1. Negative discriminant powers

Conventionally, the discriminant power DIS of a plant is positive if the fidelity to the plant is higher for the grouping than for the whole relevés. DIS is negative if the case is opposite. At the first level, the most contrasted level, the disciminant plants of a grouping have positive DIS for the grouping. They discriminate by their presence. The same plants have negative DIS for the other groupings, from which they are often absent (Fig. 2).

3.2.2. A locally missing species may be discriminant

Some plants have positive discriminant powers though they are missing from the set of relevés. It is the case, for instance, of *Erica tetralix*, in the grouping 302, for *Corylus* in the grouping 382. This means that, in the whole bank, the plants of the grouping have rather high fidelities to the locally missing plant, that is to say high fidelities to the corresponding environment.

3.3. *Gradual evolution of the discriminant plants along the hierarchy*

3.3.1. The same plant may be discriminant for a grouping and its subdivisions

On the first level, the discriminant power DIS of *Festuca ovina* is 21 per 1.000 for the upper grouping 195. On the second level, it is respectively 33 and 8 per 1.000 for the two sub-groupings (Fig. 3). Similarly, DIS of *Lotus corniculatus* is 32 for the upper grouping 195 and 40 for its sub-grouping 194. Because of their quantitative definition, a quick field diagnostic does not fit the discriminant plants in relation to their type of plant community.

3.3.2. The discriminant plants evolve gradually, along the hierarchy of the groupings, as they reflect the gradual evolution of the corresponding environments

For a sub-grouping, there are also new discriminant plants, compared to the upper grouping. For instance, for the sub-grouping 150, there are 3 new discriminant plants, which are characteristic species of classical types of plant community: *Stachys officinalis, Genista pilosa* and *Sarothamnus scoparius*. The two sub-groupings of the grouping 382 have different lists of discriminant plants, even if some of them have a similar importance: *Vaccinium myrtillus, Sorbus aucuparia, Quercus pedunculata, Rhamnus frangula* (Fig. 3).

3.4. *Characteristic species or discriminant plants?*

The notion of characteristic species confined to a type of plant community, corresponding to a type of environment, remains theoretically prominent and practically difficult, whereas the genuine characteristic species is sometimes difficult to find. Therefore, it has been proposed that the notion be associated with other kinds of specification, as the substratum and the geographical distribution of the type of plant community (Pignatti *et al.*, 1995). But the notion of discriminant plant may generalize the notion of characteristic species: 1) It has still a purely floristical base, as it acquires an ecological meaning when it uses the fidelities of plants to plants instead of the fidelities of plants to community-types. 2) It avoids a previous delimitation of the community-type. 3) It is quantitative, instead of binary, it evolves gradually between the neighbouring communities, and their corresponding environments. 4) It evolves according not only to the fidelity but also to the constancy of the plant in the groupings, without being a function of the two classical parameters. In short, discriminant plants are quantitative homologues of characteristic species.

4. Conclusion: Quantification of ecology by vegetation science

Socio-ecology may designate the part of vegetation science which quantifies the ecological differences between the plant communities on a purely floristical base. It needs a few simple statements to establish its quantification. If one agrees with the only three following statements, on is brought to use similar computations to the proposed method.

1) On a given scale, a plant community is identified by the taxa which coexist in the same environment, with a given abundance.

2) The environment of a plant community is reflected by the behaviours of its taxa.

3) The ecological behaviour of a taxon may be identified by its distribution among the diverse environments corresponding to the diverse plants.

The corresponding chain of programs applied to a thousand relevés with standardized floristical data, needs about half a day to print the classification and the characterization of the vegetation types.

RÉSUMÉ

Une méthode de classification écologique des relevés floristiques par jumelage d'une prospection régionale et d'une banque nationale de relevés. Une classification écologique des relevés floristiques a pour but d'identifier des groupements végétaux qui soient caractérisés d'après leurs seules données floristiques et qui cependant correspondent à des milieux aussi homogènes que possible. A cet effet, elle commence par étalonner le comportement de chaque plante le long d'un gradient étendu, dans une banque nationale de relevés, à l'échelle de la France, la banque SOPHY. Elle étalonne le comportement d'une plante par l'ensemble de ses fidélités aux 5.626 autres plantes de la banque, considérées comme des indices du milieu. Elle définit ainsi un espace statistique à 5.626 dimensions dans lequel: 1) un axe mesure la fidélité à une plante, considérée comme un indice du milieu; 2) un point correspond au comportement d'une plante à l'égard des indices du milieu; 3) la distance entre deux points exprime la différence écologique de deux comportements; 4) le centre de gravité des plantes d'un relevé indique la position probable du relevé; 5) la distance entre deux relevés exprime leur différence écologique.

Par comparaison, l'analyse factorielle des correspondances: 1) situe les relevés dans l'espace des fidélités des plantes aux relevés, reflétant leurs différences de composition floristique; 2) pondère les plantes par leur rareté, non par leur signification écologique; 3) traite une partie seulement des relevés à la fois et remanie cette répartition des relevés par approximations successives; 4) transpose sur des graphiques factoriels l'empirisme et l'intuition du naturaliste sur le terrain.

La méthode est illustrée par environ 400 relevés dans un canton des Vosges du Nord (France).

Elle permet de classer automatiquement les relevés à plusieurs niveaux de synthèse successifs, y compris les niveaux supérieurs aux classes phytosociologiques. Elle explique, pour moitié, l'originalité d'un groupement par 10 à 30 plantes discriminantes qui sont les homologues quantitatifs et graduels des espèces caractéristiques.

ACKNOWLEDGMENTS

These research has been supported by the «Conseil Régional de la Région Provence Alpes Côte d'Azur (PACA)».

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